NASA CR-132634

PREDICTION OF UNSTEADY AERODYNAMIC LOADINGS CAUSED BY LEADING EDGE AND TRAILING EDGE CONTROL SURFACE MOTIONS IN SUBSONIC COMPRESSIBLE FLOW -- COMPUTER PROGRAM DESCRIPTION

by

M. C. REDMAN and W. S. ROWE

Prepared under Contract No. NAS1-12020 by
THE BOEING COMPANY
RENTON, WASHINGTON

for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

May 1975

1. Report No. NASA CR-132634	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle PREDICTION OF UNSTEADY AERODYNAMIC LOADINGS CAUSED BY LEADING EDGE AND TRAILING EDGE CONTROL CONTROL SURFACE MOTIONS IN SUBSONIC COMPRESSIBLE FLOW--COMPUTER PROGRAM DESCRIPTION		5. Report Date May 1975
		6. Performing Organization Code
7. Author(s) M. C. Redman and W. S. Rowe		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address The Boeing Commercial Airplane Company P. O. Box 3707 Seattle, Washington 98124		11. Contract or Grant No. NAS1-12020
		13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C.		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

A digital computer program has been developed to calculate unsteady loadings caused by motions of lifting surfaces with leading edge or trailing edge controls based on the subsonic kernel function approach.

The pressure singularities at hinge line and side edges have been extracted analytically as a preliminary step to solving the integral equation by collocation.

The program calculates generalized aerodynamic forces for user supplied deflection modes. Optional intermediate output includes pressure at an array of points, and sectional generalized forces. From one to six controls on the half span can be accommodated.

17. Key Words (Suggested by Author(s)) Flutter, Wing-Control-Surface Flutter, Aeroelasticity, Structural Dynamics, Aerodynamics, Unsteady Aerodynamics	18. Distribution Statement Unclassified-Unlimited

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 157	22. Price*

*For sale by the National Technical Information Service, Springfield, Virginia 22151

TABLE OF CONTENTS

PREDICTION OF UNSTEADY AERODYNAMIC LOADINGS CAUSED BY LEADING EDGE AND TRAILING EDGE CONTROL SURFACE MOTIONS IN SUBSONIC COMPRESSIBLE FLOW — COMPUTER PROGRAM DESCRIPTION

By

M. C. REDMAN AND W. S. ROWE

SUMMARY

A digital computer program has been developed to calculate unsteady loadings caused by motions of lifting surfaces with leading edge or trailing edge controls based on the subsonic kernel function approach.

The pressure singularities at hinge line and side edges have been extracted analytically as a preliminary step to solving the integral equation by collocation.

The program calculates generalized aerodynamic forces for user supplied deflection modes. Optional intermediate output includes pressure at an array of points, and sectional generalized forces. From one to six controls on the half span can be accommodated.

Page Intentionally Left Blank

1.0 INTRODUCTION

This document describes in detail the design and usage of the FORTRAN IV digital computer program, RHO IV. The RHO IV program was written as an engineering tool to be used in calculation of unsteady aerodynamic loadings on lifting surfaces with leading edge or trailing edge control surfaces in compressible subsonic flow per the analysis techniques presented in reference 1.

Features of this program include:

- Modal input in the form of surface deflections at arbitrary points - Input from disk file, tape, or cards
- Calculation of unsteady pressures at arbitrary points on the lifting surface planform
- Calculation of sectional generalized forces at arbitrary spanwise locations on the lifting surface planform
- Calculation of generalized forces
- Optional saving of unsteady pressures, sectional or total generalized forces for subsequent analysis
- Optimization of computer time through the capability to save and later reuse pressure/kernel influence coefficient matrices (C-matrices)
- Capability to provide for airfoil thickness corrections using velocity profile modifications supplied by the user
- Capability to analyze up to six separate closed gap control surfaces
- Capability to analyze coupled main surface and control surface modes

Included in this document are:

- Description of equations used in the program
- Description of variable length storage requirements
- Description of user I/Ø and scratch file formats
- List of program limitations
- Description of computer program usage

- Data stacking procedures
- Description of program output - normal and diagnostic
- Sample problem input/output
- Description of program structure and routines used

2.0 DISCUSSION

2.1 GENERAL REMARKS

This section will present a description of the nomenclature and analysis as it appears in the RHO IV program. Although some information is given with each section, no attempt is made to develop or reference the sources of development of the theory involved. A full discussion of the latter is given in reference 1 of this document.

As described in reference 1, the problem of identifying the unsteady aerodynamic loading on a lifting surface without downwash discontinuities may be written as a boundary value problem.

$$W(x,y) = \frac{1}{4\pi\rho V^2} \iint \Delta P_r(\xi,\eta) \cdot K(x-\xi, y-\eta, k, M)\, d\xi d\eta \qquad (2.1\text{-}1)$$

In equation 2.1-1, the left hand side, $W(x,y)$, is the Kinematic Downwash, or effective angle of attack of the surface, due to the structural vibration mode. The right hand side of the equation is the mathematical downwash which is derived from the surface integration of unsteady pressure times an aerodynamic influence function. The latter, called the Kernel Function, is dependent upon geometry, reduced frequency, and Mach number. The unsteady pressure is unknown; however, knowing the physical characteristics of loading, the unsteady pressure may be approximated by a linear combination of Assumed Pressure Terms which will satisfy loading characteristics.

$$\Delta P_r(\xi,\eta) = 4\rho V^2 \sqrt{S^2-\eta^2}\ \Sigma a_j \Delta p_j(\xi,\eta), \quad j=1,m \qquad (2.1\text{-}2)$$

If the Downwash Integral Equation, 2.1-1, is written for a number of descrete points on the surface, (Downwash Points, or collocation points, or control points), the resulting Complex Linear System of Equations may be expressed in matrix form as,

$$\{W(x,y)\} = [C]\{a\} \qquad (2.1\text{-}3)$$

where the elements of the C-matrix are

$$C_{ij} = \frac{1}{\pi} \iint \Delta p_j(\xi,\eta)\cdot K(x_i-\xi, y_i-\eta, k, M)\,d\xi d\eta \qquad (2.1\text{-}4)$$

(Note that the C-matrix terms are independent of structural mode.) For a simple lifting surface problem, solution of 2.1-3 for the unknown coefficients of the assumed pressure terms, $\{a_j\}$, allows one to calculate the unsteady pressure at any point on the surface or integrate the unsteady pressure times modal displacements to give generalized force.

With the introduction of control surface motion relative to the remainder of the lifting surface (main surface) the problem becomes somewhat more difficult. In particular, the kinematic downwash distribution or sheet will contain a step discontinuity at the control surface with respect to the main surface. The use of additional assumed pressure terms with unknown coefficients to match the discontinuous boundary condition is prone to numeric difficulties. However, a pressure term associated with control surface rotation may be written which will give the required jump at the hinge and control surface side edge and which has a known coefficient. Thus

$$W^*(x,y) = \frac{1}{4\pi\rho V^2} \iint \Delta P_s(\xi,\eta)\cdot K(x-\xi, y-\eta, k, M)\,d\xi d\eta \qquad (2.1\text{-}5)$$

where $W^*(x,y)$ will have the same jump discontinuity at the hinge and side edge as $W(x,y)$ and will be relatively smooth away from the hinge. The control surface unsteady pressure term in equation 2.1-5 is a function of the control surface rotation at η, $\Theta(\eta)$, i.e., is dependent upon the structural mode. The control surface rotation is approximated by a cubic equation.

$$\Theta(\eta) = A_0 + A_1\underline{\eta}_{cs} + A_2\underline{\eta}_{cs}^2 + A_3\underline{\eta}_{cs}^3 \qquad (2.1\text{-}6)$$

where $\quad \underline{\eta}_{cs} = (\eta - y_i)/(y_o - y_i)$

y_i = Inboard side edge of control surface

y_o = Outboard side edge of control surface

This representation of control surface rotation should suffice for a broad range of control surface twist. The expression for the assumed control surface pressure term is then

$$\Delta P_s(\xi,\eta) = 4\rho V^2\sqrt{S^2-\eta^2}\ \sum_{1}^{4} A_{j-1}\Delta\overline{p}_j(\xi,\eta) \qquad (2.1\text{-}7)$$

If equation 2.1-5 is written for the downwash points and expressed in matrix form,

$$\{W^*(x,y)\} = [C^*]\{A\} \qquad (2.1\text{-}8)$$

where the elements of the <u>Control</u> <u>Surface</u> <u>C-matrix</u> are

$$C^*_{ij} = \frac{1}{\pi}\iint \Delta\overline{p}_j(\xi,\eta)\cdot K(x_i-\xi, y_i-\eta, k, M)\, d\xi d\eta \qquad (2.1\text{-}9)$$

and significantly, because of the polynomial representation of control surface rotation, are not dependent upon structural mode. If the kinematic downwash is modified by removing any discontinuity due to control surface rotation,

$$\overline{W}(x,y) = W(x,y) - W^*(x,y) \qquad (2.1\text{-}10)$$

the resulting residual downwash sheet, $\overline{W}(x,y)$, which is smooth, may be used to solve for the unknown coefficients of the assumed main surface pressure terms, $\{a_j\}$. The total unsteady pressure is then a combination of main surface pressure and control surface pressure.

$$\Delta P(\xi,\eta) = \Delta P_r(\xi,\eta) + \Delta P_s(\xi,\eta) \qquad (2.1\text{-}11)$$

Thus unsteady pressure may be calculated at any point on the surface or integrated to produce generalized forces as in the simple lifting surface problem.

2.2 NOMENCLATURE

The RHOIV program works with dimensional coordinates (ξ,η) and non-dimensional coordinates $(\underline{\xi},\underline{\eta})$. The b_0 reference length used in reference 1 for k value and non-dimensionalizing of all coordinates is used in RHOIV only to arrive at $k = \omega/V$ from the user input $k = b_0\omega/V$. Note that differences in nomenclature between reference 1 and this section are noted parenthetically with the symbols.

SYMBOLS	DESCRIPTION
$A(n;m,j)$	Cubic coefficients $(m=1,\ldots,4)$ in $\underline{\eta}_{cs}$ for mode j, for control surface n.
$a(m,j)$	Undetermined coefficients of assumed main surface pressure terms for mode j. $(m=1,\ldots,$no. of downwash points)
b_0	Reduced frequency reference length.
$b(\eta)$	Local planform semi-chord. $b(\eta) = 0.5[\xi_t(\eta) - \xi_l(\eta)]$
$C(x,y;m)$	C-matrix terms for downwash point (x,y) associated with assumed main surface pressure terms. $(m=1,\ldots,$no. downwash points)
$C^*(x,y,n;m)$	C-matrix terms for downwash point (x,y) associated with control surface n pressure terms. $(m=1,\ldots,4)$
C	Chordwise integral of $g(\xi,\eta)K(x_0,y_0,k,M)$, Eqn. 2.3-2.
C_1, C_2	Coefficients associated with control pressure expressions, Eqns. 2.5-11, 12.
E_1, E_2	Chordwise modification functions associated with control pressure expressions, Eqns. 2.5-16, 17.
$f(\eta;i)$	"Spanwise" portions of a pressure term. $(i=1,\ldots,$no. of chords, main surface analysis) $(i=1,\ldots,4,$ control surface analysis)

SYMBOL	DESCRIPTION
$F(x,y,\eta)$	Portion of downwash integral expression, Eqn. 2.3-6.
$G(x,y,\eta)$	Portion of downwash integral expression, Eqn. 2.3-3.
$G_{IS}, G_{S1}, G_{S2}, G_{L1}, G_{L2}, G_{AT}$	Portions of pressure expression associated with full chord control.
$g(\xi,\eta;j)$	"Chordwise" portion of pressure term, ($j=1,\ldots$,no. pts./chord, main surface) ($j=1$, control surface analysis)
H	Spanwise modification function associated with control pressure expressions, Eqn. 2.5-11.
h	Integration limit in kernel function evaluation.
i	$\sqrt{-1}$, or i-th displacement mode, or i-th "spanwise" pressure term.
I_1	Modified Bessel function.
j	j-th displacement mode, or j-th "chordwise" pressure term.
$K(x_0,y_0,k,M)$	Full kernel expression.
$K_{ns}(x_0,y_0,k,M)$	Non-singular portion of K.
$K_s(x_0,y_0,k,M)$	Singular portion of K.
K_1	Modified Bessel function
k	Reduced frequency, $k = \omega/V$.
k_r [k]	Reference reduced frequency, $k = b_0\omega/V$.
L_1	Struve function.
L_1, L_2	Portions of pressure expression associated with full chord control.
M	Mach number
$M(\xi-x_s,\eta-y_s)$	Portion of pressure expression

SYMBOL	DESCRIPTION
	associated with partial chord control.
m	A pressure term number.
$N(\xi - x_s, \eta - y_s)$	Portion of pressure expression associated with partial chord control.
n	A control surface number.
$\Delta P(\xi,\eta;j)$	Total change in pressure for mode j at point (ξ,η). P(lower)-P(upper)
$\Delta P_r(\xi,\eta;j)$	That portion of ΔP associated with the regular (assumed main surface) pressure terms.
$\Delta P_s(\xi,\eta,n;j)$ $[\Delta P_{ae}(\xi,\eta)]$	That portion of ΔP associated with the pressure terms for control surface n.
$\Delta p(\xi,\eta;m)$	The m-th assumed main surface pressure term value at (ξ,η).
$\overline{\Delta p}(\xi,\eta,n;m)$	The m-th pressure term associated with control surface n, value at (ξ,η).
q	Dynamic pressure, $q = 0.5\rho V^2$.
Q_1	Portion of pressure expression associated with full chord control.
$Q(i,j)$	Generalized force (generalized unsteady aerodynamic coefficient) for displacement mode i, pressure mode j.
$Q_r(i,j)$	That portion of Q associated with the regular (assumed main surface) pressure terms.
$Q_s(n;i,j)$	That portion of Q associated with the pressure terms for control surface n.
$\overline{Q}_r(i,m)$	Surface integral of $Z(\xi,\eta;i)\Delta p(\xi,\eta;m)$.

SYMBOL	DESCRIPTION
$Q^s(\eta;i,j)$	Sectional generalized force (sectional generalized unsteady aerodynamic coefficient) for station η, displacement in mode i, pressure in mode j.
$Q^s(\eta;i,j)$	That portion of Q^s associated with the regular (assumed main surface) pressure term.
$Q^s(\eta,n;i,j)$	That portion of Q^s associated with the pressure terms for control surface n.
$\bar{Q}^s(\eta;i,m)$	Chordwise integral of $Z(\xi,\eta;i)\Delta p(\xi,\eta;m)$.
R	A modified distance between points in kernel and control pressure expressions.
s	Planform semispan
t	Time
u $[V_1]$	Local streamwise velocity.
V	Remote freestream velocity.
$W(x,y;j)$	Kinematic downwash at (x,y) for mode j.
$W^*(x,y,n;j)$	Mathematical downwash at (x,y) for mode j due to control surface n pressure terms.
$W(x,y;j)$	Residual downwash at (x,y) in mode j; i.e. W with all control surface discontinuities removed.
w	Local normal (z) velocity.
x $[b_0 x]$	Downwash point chordwise coordinate
x_s, x_i, x_o	Control surface hinge corner (i = inboard), (o = outboard)
x_0	$x-\xi$
y $[b_0 y]$	Downwash point spanwise coordinate.
y_0	$y-\eta$

SYMBOL	DESCRIPTION
y_s, y_i, y_o	Control surface side edge (i=inboard), (o=outboard).
$z(x,y,t)$ [Z]	Time dependent modal displacement normal to surface.
$Z(x,y;i)$	Modal displacement normal to surface at (x,y) in mode i.
β	$\sqrt{1-M^2}$
β_H	$\sqrt{\beta^2+\tan^2\Lambda_H}$
β_L	$\sqrt{\beta^2+\tan^2\Lambda_L}$
η [$b_0\eta$]	Dimensional spanwise coordinate.
$\underline{\eta}$	Non-dimensional spanwise coordinate, $\underline{\eta} = \eta/S$.
$\underline{\eta}_{cs}$	Non-dimensional spanwise coordinate referenced to control surface span, $\underline{\eta}_{cs} = (\eta - y_i)/(y_o - y_i)$.
θ	"Chordwise" non-dimensional pressure term coordinate, $\theta = \cos^{-1}(-\underline{\xi})$
$\Theta(\eta)$ [Θ_H]	Control surface streamwise hinge rotation.
Λ_H	Control surface hinge sweep.
Λ_L	Control surface leading edge sweep.
ξ [$b_0\xi$]	Dimensional chordwise coordinate.
$\underline{\xi}(\eta)$	Non-dimensional chordwise coordinate, $\underline{\xi} = [\xi - \xi_m(\eta)]/b(\eta)$.
$\xi_c(\eta)$	Control surface hinge value.
$\xi_l(\eta)$	Planform leading edge value.
$\xi_m(\eta)$	Planform midchord value, $\xi_m = [\xi_t(\eta)+\xi_l(\eta)]/2$
$\xi_t(\eta)$	Planform trailing edge value.

SYMBOL	DESCRIPTION
ρ	Fluid mass density.
ϕ	"Spanwise" non-dimensional pressure term coordinate, $\phi = \cos^{-1}(\underline{\eta})$
ω	Circular frequency of oscillation.

Planview of Lifting Surface and Coordinate System

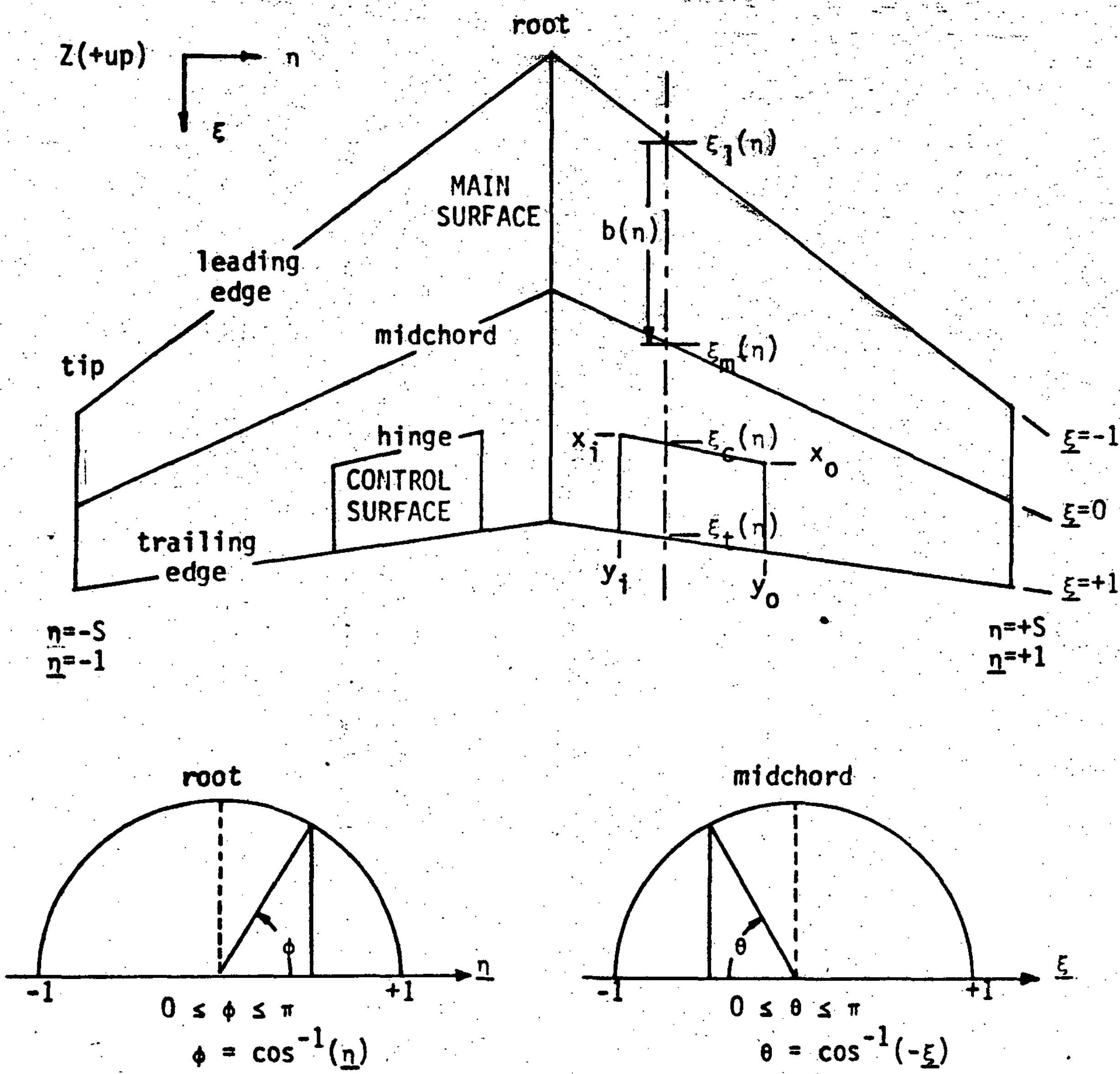


Figure 1

2.3 DOWNWASH INTEGRAL EXPRESSION

The downwash integral expression, which relates kinematic and mathematical downwash, is

$$W(x,y) = \frac{1}{\pi} \int_{-S}^{S} \sqrt{S^2-\eta^2}\,[f(\eta)C + G(x,y,y)/y_0^2 - G'(x,y,y)/y_0]d\eta \qquad 2.3\text{-}1$$

$$+ G(x,y,y) + yG'(x,y,y)$$

where C is the integral of the product of the chordwise pressure term and the kernel function,

$$C = \int_{\xi_1(\eta)}^{\xi_t(\eta)} g(\xi,\eta)K_{ns}(x_0,y_0,k,M)d\xi + \int_{\xi_1(\eta)}^{\xi_t(\eta)} g(\xi,\eta)K_s(x_0,y_0,k,M)d\xi \qquad 2.3\text{-}2$$

and $G(x,y,y)$ and $G'(x,y,y)$ are related to the evaluation of the dipole singularity; see reference 1.

$$G(x,y,\eta) = f(\eta)F(x,y,\eta) \qquad 2.3\text{-}3$$

$$G'(x,y,\eta) = \partial G(x,y,\eta)/\partial\eta = f'(\eta)F(x,y,\eta) + f(\eta)F'(x,y,\eta) \qquad 2.3\text{-}4$$

$$G(x,y,y) = \lim_{\eta\to y} G(x,y,\eta) \qquad 2.3\text{-}5$$

where $\Delta p(\xi,\eta) = f(\eta)g(\xi,\eta)$ is the loading function, and

$$F(x,y,\eta) = \int_{\xi_1(\eta)}^{\xi_t(\eta)} g(\xi,\eta)[1 + x_0/\sqrt{x_0^2 + \beta^2 y_0^2}]e^{ikx_0}d\xi \qquad 2.3\text{-}6$$

$$F(x,y,y) = 2\cdot\int_{\xi_1(y)}^{x} g(\xi,y)e^{ikx_0}d\xi \qquad 2.3\text{-}7$$

$$F'(x,y,\eta) = \partial F(x,y,\eta)/\partial\eta \qquad 2.3\text{-}8$$

$$F'(x,y,y) = 2\cdot\int_{\xi_1(y)}^{x} [\partial g(\xi,y)/\partial\eta]e^{ikx_0}d\xi \qquad 2.3\text{-}9$$

Note that integration by parts, or a similar approach, is required in equation 2.3-9 for those terms, $\partial g(\xi,y)/\partial\eta$, which contain a singularity in the interval, see reference 1.

Note also, that the spanwise integrand associated with the singular kernel, i.e.,

$$\sqrt{S^2-\eta^2}\left[f(\eta)\int_{\xi_1(\eta)}^{\xi_t(\eta)} g(\xi,\eta)K_s(x_0,y_0,k,M)\,d\xi + G(x,y,y)/y_0^2 - G'(x,y,y)/y_0\right]$$

is of the form,

$$\ln|y_0/S|\,(\text{regular function}) + (\text{regular function})$$

which requires log quadrature to be used around a downwash chord for that portion of the spanwise integrand.

2.4 KERNEL FUNCTION

The kernel function is an aerodynamic influence function relating the induced normal velocity at an arbitrary field point to a unit loading on a surface at some other point. In the case of a flat plate lifting surface, only the planar portion of the kernel is used. This may be written,

$$K_s(x_0,y_0,k,M) = k^2e^{-ikx_0}\{-(R+kx_0)/(Rk^2y_0^2) + i/R - (kx_0-MR)/(2\beta^2R) -\ln|(R-kx_0)/(2-2M)|/2\} \qquad 2.4\text{-}1$$

where $R = \sqrt{k^2x_0^2 + \beta^2k^2y_0^2}$

The expression 2.4-1 has been shown to contain a number of singularities which cause numerical integration to be extremely expensive. The singularities have been identified and may be analytically subtracted from the full expression yielding a nonsingular function. The form of the singular portion of the kernel is

$$K(x_0,y_0,k,M) = -e^{ikx_0}\frac{1}{y_0}\frac{\partial}{\partial y_0}\int_{-\infty}^{h}[e^{ik\lambda}/\sqrt{\lambda^2+y_0^2}]d\lambda \qquad 2.4\text{-}2$$

where $h = [x_0-M\sqrt{x_0^2+y_0^2}]/\beta^2$

which reduces to eqn. 2.4-3 when k=0.

$$K_s(x_0,y_0,0,M) = -\{1 + x_0/\sqrt{x_0^2 + \beta^2y_0^2}\}/y_0 \qquad 2.4\text{-}3$$

The singular portion is integrated separately from the nonsingular portion. Because of its singular nature, it requires a large number of evaluations when numerical integration is being performed; however, it is relatively inexpensive to evaluate. The nonsingular function is slightly more expensive to evaluate than the full kernel; however, because of its regular nature, it is evaluated much less during numerical integration.

Two forms of the nonsingular kernel are used. The first, Watkin's formulation, is faster to calculate (and numerically sufficiently accurate) for values of $k|y_0|\geq 1.0$. The second, Rosel's formulation, requires longer to calculate (particularly as $k|y_0|$ becomes large), but is numerically more accurate for $k|y_0|\leq 1.0$.

For Watkin's form, defining

$$I_a = \int_0^{h/|y_0|} [\tau e^{ik|y_0|\tau} / \sqrt{1+\tau^2}] d\tau \qquad 2.4\text{-}4$$

The form of the full kernel expression is

$$K(x_0,y_0,k,M) = k^2 e^{ikx_0}\{-K_1(k|y_0|)/k|y_0| - i.5\pi[I_1(k|y_0|)-L_1(k|y_0|)]/k|y_0| + i/k|y_0| - kx_0 e^{ikh}/k^2y_0^2 + I_a\} \qquad 2.4\text{-}5$$

The two expressions, Eqns. 2.4-2,5 are combined to give the nonsingular form.

$$K_{ns}(x_0,y_0,k,M) = K(x_0,y_0,k,M) - K_s(x_0,y_0,k,M) \qquad 2.4\text{-}6$$

In Eqn. 2.4-4, the term $\tau/\sqrt{1+\tau^2}$ is approximated by an exponential series, reference 6, which may be integrated analytically.

For Rosel's form, the nonsingular kernel is written directly,

$$\begin{aligned} K_{ns}(x_0, y_0,k,M) = k^2e^{-ikx_0}\{ & \int_{-kf}^{kh}[(e^{i\lambda}-1-i\lambda+\lambda^2/2)/(\lambda^2+k^2y_0^2)^{3/2}]d\lambda \\ & + \int_{-\infty}^{-kf}[e^{i\lambda}/(\lambda^2+k^2y_0^2)^{3/2}]d\lambda \\ & + M(e^{ikh}-1-ikh+k^2h^2/2)/(\sqrt{k^2x_0^2+\beta^2k^2y_0^2}\sqrt{k^2h^2+k^2y_0^2}) \\ & + ik/\sqrt{k^2f^2+k^2y_0^2} - 1/[\sqrt{k^2f^2+k^2y_0^2}(\sqrt{k^2f^2+k^2y_0^2} + kf)] \\ & -.5k^2(\ln[(\sqrt{k^2f^2+k^2y_0^2} + kf)/2] - kf/\sqrt{k^2f^2+k^2y_0^2})\} \end{aligned} \qquad 2.4\text{-}7$$

where the singular terms (the same as in Eqn. 2.4-2) are already removed. The exponentials in the integrals are written as infinite series and integrated analytically. The resulting infinite series of terms, which may be calculated in a recursive manner, are truncated when a predetermined conversion criteria is met.

2.5 LOADING FUNCTIONS

The loading functions used within RHOIV are of two types. The regular, or main surface, pressure terms are used to match the regular boundary condition associated with a simple lifting surface or the residual boundary condition associated with a lifting surface with controls when the control discontinuities have been removed. The singular, or control surface, pressure terms are used to match the <u>change</u> in boundary condition at a control surface <u>hinge</u> or <u>side</u> <u>edge</u>.

The regular pressure is assumed to be of the form

$$\Delta P_r(\xi,\eta) = 4\rho V^2\sqrt{S^2-\eta^2}\ \sum_m \Delta p(\xi,\eta;m)a(m) \qquad 2.5\text{-}1$$

$$= 4\rho V^2\sqrt{S^2-\eta^2}\ \{\Delta p(\xi,\eta;m)\}'\{a(m)\}$$

where a(m) are unknown coefficients. The term $\sqrt{S^2-\eta^2}$ has been included in the coefficient to simplify evaluation of the dipole singular portion of the downwash integral expression.

The assumed main surface pressure terms, $\Delta p(\xi,\eta)$, are themselves composed of a "spanwise" and a "chordwise" term, e.g.

$$\Delta p(\xi,\eta;m) = f(\eta;i)g(\xi,\eta;j) \qquad 2.5\text{-}2$$

The set $\Delta p(\xi,\eta)$ is composed of all combinations of spanwise, $f(\eta)$, and chordwise, $g(\xi,\eta)$, terms. For the determined case, the number of spanwise terms is equal to the number of downwash chords (=NSPT), and the number of chordwise terms is equal to the number of points per downwash chord (=NCPT).

The spanwise terms used are

$$f(\eta;i) = \sin[(2\cdot i-N)\phi]/\sqrt{S^2-\eta^2}, \quad i = 1,\dots,NSPT \qquad 2.5\text{-}3$$

where $\phi = \cos^{-1}(\underline{\eta})$, $\underline{\eta} = \eta/S$
$N = 1$ for a symmetric analysis,
$= 0$ for an antisymmetric analysis

The chordwise terms used are

$$g(\xi,\eta;1) = \cot(\theta/2) \qquad 2.5\text{-}4$$

$$g(\xi,\eta;j) = \sin[(j-1)\theta], \quad j = 2,3,\dots,NCPT$$

where $\theta = \cos^{-1}(-\underline{\xi})$, $\underline{\xi} = (\xi - \xi_m(\eta))/b(\eta)$

Note that all $\Delta p(\xi,\eta)$ go to zero at the planform trailing edge and tip as the square root of the distance. The terms which are not associated with $g(\xi,\eta;1)$ go to zero at the leading edge in a similar manner. The terms which are associated with $g(\xi,\eta;1)$ have the inverse square root singular form which is required at the leading edge. Note also that $f(0;i)$ is plus or minus one for a symmetric analysis, and zero for an antisymmetric analysis.

The (i,j) combinations of Eqn. 2.5-2 are ordered ((i=1,...,NSPT),j=1,..NCPT).

The singular pressure expression associated with a control surface is of the form,

$$\Delta P_s(\xi,\eta) = \rho V^2 \Theta(\eta) g(\xi,\eta)/\pi \qquad 2.5\text{-}5$$

where as indicated in Eqn. 2.1-6 the streamwise control rotation, $\Theta(\eta)$, is represented as a cubic,

$$\Theta(\eta) = \sum_1^4 A(m)\underline{\eta}_{cs}^{m-1} \qquad 2.5\text{-}6$$

$$\underline{\eta}_{cs} = (\eta-y_i)/y_o-y_i)$$

Defining the "spanwise" pressure terms to be,

$$f(\eta;i) = \underline{\eta}_{cs}^{i-1}/4\pi\sqrt{S^2-\eta^2} \qquad 2.5\text{-}7$$

Equation 2.5-5 becomes,

$$\Delta P_s(\xi,\eta) = 4\rho V^2 \sqrt{S^2-\eta^2}\{\Delta p(\xi,\eta;m)\}'\{A(m)\} \qquad 2.5\text{-}8$$

where $\Delta p(\xi,\eta;m) = f(\eta;i)g(\xi,\eta)$ 2.5-9

The "chordwise" portion, $g(\xi,\eta)$, is composed of a pressure term from each side edge,

$$g(\xi,\eta) = g(\xi,\eta,y_o)-g(\xi,\eta,y_i) + S_f[\ g(\xi,\eta,-y_o)-g(\xi,\eta,-y_i)\ ] \qquad 2.5\text{-}10$$

where

y_o,y_i = Outboard and inboard side edges for right hand side of planform

$-y_o,-y_i$ = Outboard and inboard side edges for left hand side of planform

S_f = +1 for a symmetric analysis, -1 for an antisymmetric analysis

The terms $g(\xi,\eta,y_s)$ consist of a portion derived, reference 1, in an asymptotic expansion process to satisfy the change in

boundary conditions across the hinge and side edge, and modification functions which maintain the necessary singular characteristics at the hinge and side edge but cause the total expression to have the correct characteristics at the planform boundaries. Two boundary value problems are used: (1) partial chord control, (2) full chord control. The partial chord expression is used for all side edges associated with trailing edge controls. The partial chord expression is subtracted from the full chord expression for all side edges associated with leading edge controls.

The spanwise modification function used for both the partial chord and full chord expression is

$$H(\eta) = \sqrt{1-C}\,(1 + .5C + .375C^2),\ C = |\eta-y_s|/|\pm S-y_s| \qquad 2.5\text{-}11$$

The following coefficients are used independently of side edge for the partial chord control expression.

$$C_1 = [-(1+k^2M^2/4\beta^2\beta_H^2 + M^2/\beta_H^2 + .5)/\beta_H - i(\xi-\xi_c)(2k + M^2/\beta_H^2)/\beta_H] \qquad 2.5\text{-}12$$

$$C_2 = [(\xi-\xi_c)k^2(1 + .5\tan\Lambda_H) - 2ik] \qquad 2.5\text{-}13$$

The contribution to $g(\xi,\eta)$ for each partial chord side edge is then,

$$g(\xi,\eta,y_s) = H(\eta)[C_1E_1M(\xi-x_s,\eta-y_s) + C_2E_2(\eta-y_s)N(\xi-x_s, -y_s)] \qquad 2.5\text{-}14$$

where
$$E_1 = \sqrt{(2\xi_c-\xi_1-\xi)(\xi-\xi_1)/(\xi_c-\xi_1)} \quad \text{for } \xi<\xi_c \qquad 2.5\text{-}15$$

$$\sqrt{(\xi_t-\xi)(\xi-2\xi_c+\xi_t)/(\xi_t-\xi_c)} \quad \text{for } \xi>\xi_c$$

$$E_2 = [(\xi-\xi_1)^2(\xi_t-\xi)^2/\{(\xi-\xi_1)^2+(\eta-y_s)^2\}\{(\xi_t-\xi)^2+(\eta-y_s)^2\}]^{1/4} \qquad 2.5\text{-}16$$

$$M(\xi-x_s,\eta-y_s) = \ln[R-(\beta^2(\eta-y_s)+(\xi-x_s)\tan\Lambda_H)/\beta_H] \qquad 2.5\text{-}17$$

$$N(\xi-x_s,\eta-y_s) = \ln[R-(\xi-x_s)] \qquad 2.5\text{-}18$$

and
$$R = \sqrt{(\xi-x_s)^2+\beta^2(\eta-y_s)^2} \qquad 2.5\text{-}19$$

Note that $C_1, C_2, M,$ and N were derived using the asymptotic expansion process; E_1 and E_2 are chordwise modification functions.

The following coefficients which are independent of (ξ,η) are side edge dependent in the full chord control expression.

where $C_1 = 1 - ik(x_c - x_1)$ 2.5-20

$$C_2 = k(-(x_c - x_1)kM^2/\beta^2 + i(\beta^2 - M^2)/\beta^2) \qquad 2.5\text{-}21$$

$$(x_c - x_1) = (\xi_c(y_s) - \xi_1(y_s))$$

The following terms are dependent upon side edge and upon (ξ, η) in the full chord control expression.

$$G_{IS} = E_3 Q_1/\sqrt{\xi - \xi_1} \qquad 2.5\text{-}22$$

$$G_{S1} = E_3\sqrt{\xi - \xi_1}\; Q_1 \qquad 2.5\text{-}23$$

$$G_{S2} = E_3\sqrt{\xi - \xi_1}\; (C_1 L_2 + C_2 L_1) \qquad 2.5\text{-}24$$

where

$$Q_1 = \beta \mathrm{sign}(\eta - y_s)L_1 + \tan\Lambda_L L_2 \qquad 2.5\text{-}25$$

$$L_2 = \sqrt{R - (\xi - \xi_c(y_s))} \qquad 2.5\text{-}26$$

$$L = \sqrt{R + (\xi - \xi_c(y_s))} \qquad 2.5\text{-}27$$

$$R = \sqrt{(\xi - \xi_c(y_s)) \;\; + \beta^2(\eta - y_s)^2} \qquad 2.5\text{-}28$$

and $C_1 = \tan\Lambda_L + ik[2(\xi - \xi_c(y_s))\tan\Lambda_L - (3\beta_L^2 - 2\beta^2)(\eta - y_s)]/4\beta^2$ 2.5-29

$$C_2 = 1 + ik^2(\xi - \xi_1(\eta))/2\beta^2 \qquad 2.5\text{-}30$$

and the chordwise modification function E_3 is,

$$E_3 = \sqrt{3 - 2\underline{\xi} - \underline{\xi}^2}\;/2 \qquad 2.5\text{-}31$$

additionally,

$$G_{L1} = (\eta - y_s)[E_3 \ln((C_1 + C_2)^2) - E_2 \ln(\beta_L^2(\eta - y_s)^2)] \qquad 2.5\text{-}32$$

$$G_{L2} = [1 + ik^2(\xi - \xi_1(y_s) - .75\tan\Lambda_L(\eta - y_s))/\beta^2]G_{L1} \qquad 2.5\text{-}33$$

where $C_1 = L_2^2 - \tan\Lambda_L(\eta - y_s)$ 2.5-34

$$C_2 = \sqrt{2}\;\sqrt{\xi - \xi_1(y_s)}\; L_2 \qquad 2.5\text{-}35$$

and the chordwise modification function E_2 is

$$E = [(\xi_t - \xi)^2\{(\xi_t - \xi_1)^2 + \beta^2(\eta - y_s)^2\}/(\xi_t - \xi_1)^2\{(\xi_t - \xi)^2 + \beta^2(\eta - y_s)^2\}]^{1/4} \qquad 2.5\text{-}36$$

and finally,

$$G_{AT} = E_2\beta \mathrm{sign}(\eta - y_s)\; \arctan(C_1/C_2) \qquad 2.5\text{-}37$$

where $C_1 = \sqrt{2}\sqrt{\xi-\xi_l(y_s)}\ L_1$ 2.5-38

$C_2 = L_l^2 + (\eta-y_s)\tan\Lambda_L$ 2.5-39

Note that all terms except E_2 and E_3 were derived using the asymptotic expansion process.

The contribution of each full chord side edge to $g(\xi,\eta)$ is

$$g(\xi,\eta,y_s) = [C_{IS}G_{IS}+C_{S1}G_{S1}+C_{S2}G_{S2}+C_{L1}G_{L1}+C_{L2}G_{L2}+C_{AT}G_{AT}] \cdot [e^{ik^2M^2\{\xi-\xi_l(y_s)\}/\beta^2}] \quad 2.5\text{-}40$$

2.6 DOWNWASH DEFINITION

The left hand side of the downwash integral equation is the kinematic downwash, or kinematic angle of attack, $W(x,y)$. The kinematic downwash, which is derived from the modal displacements for some structural vibration mode, is the boundary condition which must be satisfied by the as yet unknown pressure distribution under the integral equation 2.3-1.

The following is applicable for any mode j; the subscript is omitted. Reference 1 presents a more detailed derivation and explanation.

If the equation of the surface of a general body in a flow field is written, $F(x,y,z,t) = 0$, the condition of no flow through the body is

$$DF/Dt = \partial F/\partial t + (\partial F/\partial x)u + (\partial F/\partial y)v + (\partial F/\partial z)w \qquad 2.6\text{-}1$$

where DF/Dt is the substantial derivative with respect to time. When the body is a flat plate undergoing sinusoidal motion,

$$z(x,y,t) = Z(x,y)e^{i\omega t} \qquad 2.6\text{-}2$$

The velocity normal to the surface, w, can be written,

$$w = -[\partial z/\partial t + (\partial z/\partial x)u + (\partial z/\partial y)v]e^{i\omega t}$$

$$= -[(\partial Z/\partial x)u + (\partial Z/\partial y)v + i\omega Z]e^{i\omega t} \qquad 2.6\text{-}3$$

Assuming there is no spanwise flow, the kinematic downwash (amplitude ratio), $W = (w/V)e^{i\omega t}$, is

$$W(x,y) = -[(\partial Z(x,y)/\partial x)(u/V) + ikZ(x,y)] \qquad 2.6\text{-}4$$

where the term (u/V), called the <u>Velocity Profile</u>, is identically one for a flat plate. A first order approximation of thickness effects may be introduced using a velocity profile which is not identically one, see reference 2. This modification of the real part of the boundary condition is particularly significant when attempting to calculate control hinge moments for non-flat plate airfoil sections.

The RHOIV program will, at the user's option, generate an additional kinematic downwash column for a gust analysis. The forms available are

$$W(x,y) = [\cos(\Phi) - i\bullet\sin(\Phi)] \qquad 2.6\text{-}5$$

$\Phi = [k(x-x_{ref})]$, x_{ref} = a zero phase gust reference point

which is referred to as a gradual penetration gust, and

$$W(x,y) = [1 - 0i] \qquad 2.6\text{-}6$$

which is referred to as a discrete gust.

2.7 SOLUTICN FOR UNDETERMINED COEFFICIENTS

In order to solve for the unknown coefficients of the assumed main surface pressure terms, a(m,j), the kinematic downwash, W(x,y;j), is first modified by removing the mathematical downwash, W*(x,y,n;j), associated with each control surface in the analysis. The resulting residual downwash, $\overline{W}$(x,y;j), which is smooth and continuous, is used in the set of linear equations which is solved for the unknown coefficients:

$$[\overline{W}(x,y;j)] = [W(x,y;j)] - [W^*(x,y,n;j)] \qquad 2.7\text{-}1$$

where

$$[W^*(x,y,n;j)] = [C^*(x,y,n;m)][A(n;m,j)] \qquad 2.7\text{-}2$$

then $[C(x,y;m)][a(m,j)] = [\overline{W}(x,y;j)]$ 2.7-3

2.8 UNSTEADY PRESSURES, SECTIONAL AND TOTAL GENERALIZED FORCES

The final results generated by the RHOIV program consist of delta pressures and generalized forces. The pressures are determined by evaluating the various pressure terms used at the desired output points and combining with the required coefficients. The generalized forces are determined by integrating pressures times modal displacements for all combinations of modes used. Sectional forces involve integrating along a chord; total forces involve integrating over the area of the planform half span.

All program output has the coefficient of $q = 0.5\rho V^2$.

The pressure at any point (ξ,η) for some mode j is composed of a contribution from the assumed main surface pressure terms and a contribution from the pressure terms associated with each control surface.

$$\Delta P(\xi,\eta;j) = \Delta P_r(\xi,\eta;j) + \sum_n \Delta P_s(\xi,\eta,n;j) \qquad 2.8\text{-}1$$

where

$$\Delta P_r(\xi,\eta;j) = 4\rho V^2\sqrt{S^2-\eta^2}\{\Delta p(\xi,\eta;m)\}'\{a(m,j)\} \qquad 2.8\text{-}2$$

= contribution from assumed main surface pressure terms

$$\Delta P_s(\xi,\eta,n;j) = 4\rho V^2\sqrt{S^2-\eta^2}\{\overline{\Delta p}(\xi,\eta,n;m)\}'\{A(n;m,j)\} \qquad 2.8\text{-}3$$

= contribution from control surface n pressure terms

Note that the terms $\Delta p(\xi,\eta;m)$ can be calculated independently of k value and Mach number. The program output for pressures, $\Delta P(\xi,\eta;j)/q$, has dimensions of (modal displacement units)/planform length units).

The sectional forces at a spanwise station η for the combination of i displacement mode and j pressure mode are also composed of contributions from main surface and control surface pressure terms.

$$Q^s(\eta;i,j) = \int_{\xi_1(\eta)}^{\xi_t(\eta)} Z(\xi,\eta;i)\,\Delta P(\xi,\eta;j)\,d\xi \qquad 2.8\text{-}4$$

$$[Q^s(\eta;i,j)] = [Q^s_r(\eta;i,j)] + \sum_n [Q^s_s(\eta,n;i,j)] \qquad 2.8\text{-}5$$

where

$$[Q_r^s(\eta;i,j)] = [\overline{Q}^s(\eta;i,m)][a(m,j)] \qquad 2.8\text{-}6$$

= contribution from assumed main surface pressure terms

$$[\overline{Q}^s(\eta;i,m) = 4\rho V^2\sqrt{S^2-\eta^2}\int_{\xi_1(\eta)}^{\xi_t(\eta)} Z(\xi,\eta;i)\,\Delta p(\xi,\eta;m)\,d\xi \qquad 2.8\text{-}7$$

Note that $\overline{Q}^s$ may be calculated independently of k value and Mach No.

$$[Q_s^s(\eta,n;i,j)] = 4\rho V^2\sqrt{S^2-\eta^2}\left[\int_{\xi_1(\eta)}^{\xi_t(\eta)} Z(\xi,\eta;i)\,\Delta\overline{p}(\xi,\eta,n;m)\,d\xi\right][A(n;m,j)] \qquad 2.8\text{-}8$$

= contribution from control surface n pressure terms

The program output for sectional forces, $[Q^s(\eta;i,j)]/q$, has dimensions of (modal displacement units)^2.

Similarly, the total generalized forces are given by

$$Q(i,j) = \int_0^S\int_{\xi_1(\eta)}^{\xi_t(\eta)} Z(\xi,\eta;i)\,\Delta P(\xi,\eta;j)\,d\xi\,d\eta \qquad 2.8\text{-}9$$

$$[Q(i,j)] = [Q_r(i,j)] + \sum_n [Q_s(n;i,j)] \qquad 2.8\text{-}10$$

where

$$[Q_r(i,j)] = [\overline{Q}_r(i,m)][a(m,j)] \qquad 2.8\text{-}11$$

= contribution from assumed main surface pressure terms

$$\overline{Q}_r(i,m) = 4\rho V^2\int_0^S\int_{\xi_1(\eta)}^{\xi_t(\eta)}\sqrt{S^2-\eta^2}\; Z(\xi,\eta;i)\,\Delta\overline{p}(\xi,\eta;m)\,d\xi\,d\eta \qquad 2.8\text{-}12$$

Note that $\overline{Q}_r$ may be calculated independently of k value and Mach No.

$$[Q_s(n;i,j)] = 4\rho V^2\left[\int_0^S\int_{\xi_1(\eta)}^{\xi_t(\eta)}\sqrt{S^2-\eta^2}\,Z(\xi,\eta;i)\,\Delta\overline{p}(\xi,\eta,n;m)\,d\xi\,d\eta\right][A(n;m,j)] \qquad 2.8\text{-}13$$

= contribution from control surface n pressure terms.

The program output for total forces, $[Q(i,j)]/q$, has the dimensions of (planform length units)$\cdot$(modal displacement units)^2.

Page Intentionally Left Blank

3.0 COMPUTER PROGRAM USAGE

3.1 MACHINE REQUIREMENTS

The RHO IV program system is written for the CDC 6000 series computer. It requires the use of a card reader, line printer, disk storage, a minimum of zero and a maximum of five tape drives.

3.2 OPERATING SYSTEM

The program runs under the SCOPE 3.1 or KRONOS operating systems. All system routines used are assumed to be standard CDC release. With the exception of COMPASS routines used for shifting and vector inner products, all source routines are coded in CDC 6600 FORTRAN IV. The overlay loading feature is used.

3.3 STORAGE ALLOCATION

The RHO IV program will load under a field length of 37000_8.

The program has been written to use blank common as a working area for those portions of the analysis which are dependent upon the size of the user's problem. Specifically, there is no program limitation on the number of modes, modal input points, pressure output points, or sectional force output chords.

The minimum core requirement of 53000_8 words is determined by C-matrix calculation in which variable dimensioning is not used.

The requirements for the other sections will be calculated and printed at execution time; they may be precalculated using the formulae below. Some examples of required field lengths for selected problems is given following the equations. Note only those sections which will be used need be considered.

The following variables are used in describing core requirements:

1.	NOVP	Number of user supplied velocity profiles
2.	NVPP(I)	Number of points associated with velocity profile I. (Refer to user input, page 64)
3.	NPRC	Number pressure output chords
4.	NPPT	NPRC*NPPRC
5.	NSGFC	Number of sectional force output chords (Refer to user input, page 66. Note that default values may be supplied by the program.)
6.	NOCS	Number of control surfaces
7.	NIPTS(I)	Number of modal input points for zone I

8. MIPTS Max [NIPTS(I), I=1, NOCS+1]
9. NZONES Number of modal input zones, =NOCS+1
10. NDMDS Number of displacements modes
11. NPMDS Number of pressure modes
= NDMDS if .NOT.GUST
= NDMDS+1 if GUST
(Refer to user input, page 68)

12. NDWP Number of downwash points = NDWC*NPDWC
13. NPTRM Number of assumed main surface pressure terms
(=NDWP currently)
(Refer to user input, page 66)

14. LIIA Length of IIA information
15. LVP Length of velocity profile information
16 LCCR Length of control rotation information
17. MPCHD Maximum number of points/chord required for sectional or total generalized forces
18. MICHD Maximum number of chords required for generalized force integration
19. LINDEX Length of CMFILE index
(Refer to discussion below)

(1) The interpolation information arrays are used to calculate control rotation coefficients, basic downwash matrix, and sectional and total generalized force precalculated information. The length involved is,

(a) LIIA = The sum of the lengths of all IIA arrays input by user (IIAIN=.TRUE.), or

(b) LIIA = NZONES*(3*NDMDS+23) + (NDMDS+4)*Sum[NIPTS(I), I=1,NZONES]

(2) If controls are present, control rotation coefficients are used in all preparation routines. The length involved is,

LCCR = 4*NOCS*NDMDS

(3) If velocity profiles are used, cubic splines are generated for each profile, and the information used in calculation of control rotations and the basic downwash matrix.

LVP = 5*Sum[NVPP(I),I=1,NOVP] - NOVP

(4) For the purpose of performing sectional and total generalized force integration, maximums can be placed on the number of integration chords and points/chord which will be required. The maximum number of points/chord required for sectional or total generalized force integration is,

MPCHD = 22 + (4*NOCS+12) if NOCS>0

The maximum number of chords required for total generalized force integration is,

MICHD = 17 + 8*NOCS

(5) If a user supplied CMFILE is present, a CMFILE index is required. The length of a CMFILE index is,

LINDEX = 13*No. Main Surface C-matrices + No. Control Surface C-matrices

A minimum for each of the sections is given, followed by additive amounts for each subsection. The core required is the maximum required for any section used. The requirement for a section is the section minimum plus maximum required for any subsection used.

I.	<u>INPUT PREPARATION</u>	51000_8 + Minimum of 1440_8
	A. Velocity profile input	7*Max[NVPP(I),I=1,NOVP]-4
	B. Pressure results input	NPRC + NPPT
	C. Sectional force results input	NSGFC
	D. Modal input	1a.MIPTS*(NDMDS+4) or b.Maximum size of user input IIA
II.	<u>MODAL INPUT PREPARATION</u>	37000_8 + LVP
	A. Calculation of interpolation information	1. MIPTS*(NDMDS+2)+9*NDMDS +2a.(MIPTS+3)**2MIPTS+3 or b.23+3*(MIPTS+NDMDS)+MIPTS*NDMDS
	B. Calculation of control rotation coefficients	NZONES+LIIA+LCCR+3*NDMDS
III.	<u>RESULT PREPARATION</u>	37000_8 +NZONES +LIIA + LCCR
	A. Formation of basic kinematic downwash matrix	LVP+NDWP*(2*NPMDS+3)+NOCS+1

B. Unsteady pressure results preparation
: 1. NPRC+NPPT
+2a. NPPT*NPTRM
or b. NPRC*NPMDS*NOCS

C. Sectional force preparation
: 1. NZONES+3*MPCHD+NPMDS
+2a. NDMDS*NPTRM
or b. MPCHD*NPMDS
+3. NSGFC

D. Generalized force results preparation
: 1.,2. as in C above
+3. 2*MICHD

IV. <u>C-MATRIX CALCULATION</u> 53000_8

V. <u>C-MATRIX LIBRARY USAGE</u> 35000_8 + LINDEX + NDWP*NPTRM*2

VI. <u>SOLUTION SECTION</u> 35000_8

A. C-matrix/downwash matrix printed output
: 1a. 2*NDWP*NPTRM
or b. NOCS*(8*NDWP+4*NDMDS)+8*NDWP

B. Solution for coefficients of main surface pressure terms
: 1. NDWP*(2*NPTRM+N)
+2. NOCS*(8*NDWP+4*NPMDS)

Note that the value of N is selected on the user's field length, N=minimum of 3, maximum of 1+2*NPMDS.

C. Pressure coefficient output
: 8*NPTRM

VII. <u>RESULTS</u> 35000_8

A. Unsteady pressure calculation
: 1. NPRC+NPPT*(NPTRM+6)
+2a. 2*NPTRM
or b. 2*NPRC*NOCS
or c. 4*NPPT
+3. 2*NPPT (if NOCS>0)

B. Sectional force calculation
: 1. 2*NDMDS*NPMDS
+2a. NDMDS*NPTRM+2*NPTRM
or b. 119+20*NOCS (if NOCS>0)
+3. NSGFC

C. Generalized force calculation
: 1.,2. as in B above

In order to provide a user with an easily determined initial field length estimate the preceding equations have been applied for several combinations of user controlled parameters.

The following field length requirements are for a lifting surface with two (2) control surfaces where the assumption is made that the maximum number of input points per input zone is no more than 75% of the total number of input points. The field lengths have been rounded up to the nearest 5000_8.

Total No. Input Pts.	No. Modes	No. Downwash Pts.	No. Pressure Output Pts.	FL Required 1000_8
200	100	72	231	155
			100-0	150
		35	231-100-0	150
	40	72-35	231-100-0	130
	4	72-35	231-100-0	115
100	100	72	231-100-0	125
		35	231-100-0	105
	40	72	231	110
			100-0	65
		35	231	70
			100-0	60
	4	72	231	105
			100-0	60
		35	231	65
			100-0	minimum
7	4	72	231	105
			100-0	60
		35	231	65
			100-0	minimum

3.4 TIMING

The central processor time required to execute any problem is almost entirely dependent upon the number of C-matrices which must be calculated. A large (>90%) reduction in CP (central processor) time may be gained by utilizing previously generated C-matrices (refer to Section 3.5.2).

The principle factors in the CP time required to calculate a C-matrix are (1) the number of downwash points, (2) whether the matrix is associated with the main surface, a trailing edge control surface, or leading edge control surface, and (3) whether the condition is steady state $(k=0)$, or unsteady $(k \neq 0)$.

Items (2) and (3) plus planform shape and position of a downwash point on the planform will determine the CP time required for each downwash point. The values given below are average requirements for the sample problem of Section 3.9.

SURFACE	CONDITION	CP SECONDS/DOWNWASH PT.
MAIN	$k = 0$	1.0
	$k > 0$	3.0
TRAILING EDGE CONTROL	$k = 0$	3.0
	$k > 0$	11.0
LEADING EDGE CONTROL	$k = 0$	11.0
	$k > 0$	27.0

The above values may be used initially to estimate CP time required for a users problem. Note that a C-matrix must be calculated or retrieved from a library for the main surface and each control surface in the problem for each condition. At execution time the RHO IV program prints the specific CP time required per downwash point for any C-matrix calculated as well as printing a breakdown of CP usage by the various other sections of the program.

3.5 FILE I/O

3.5.1 File Utilization

RHO IV uses standard input and output, two internal scratch files, and up to five (5) user specified input/output files. The scratch files are referenced in the program by different names, dependent upon the usage. All user input/output files have the record format described below for READM/WRITEM.

The files referenced are:

(1)	INPUT	Standard input (BCD)
(2)	OUTPUT	Standard output (BCD)
(3)	RHOSC1	Scratch file (binary)
	(MISFILE)	Modal input scratch file
	(RESFILE)	Result scratch file
(4)	RHOSC2	Scratch file (binary)
	(INSFILE)	Input scratch file
	(CMSFILE)	C-matrix scratch file
	(COFFILE)	Coefficient file
(5)	MIFILE	Modal input file, user specified file for input modal displacements and associated points (binary)
(6)	CMFILE	C-matrix file, user specified input/output file containing the library of previously calculated C-matrices. (binary)
(7)	DPFILE	Pressure output file, user specified output file containing all unsteady pressure results
(8)	SGFFILE	Sectional force output file, user specified output file containing all sectional force results.
(9)	GFFILE	Generalized force output file, user specified output file containing all generalized force results.

Note that the user specifies the file names for (5)-(9) in data input. Files (5),(7)-(9) may be equivalenced in any combination using one or more file names, the output for (7)-(9) will then be interleafed on a k-value, Mach number condition basis.

If a CMFILE is defined it must be descrete.

The user may also specify an initial file position for (5)-(9). MIFILE is positioned and used, then DPFILE, SGFFILE, and GFFILE are positioned, in that order. Therefore if a user gives two or more files the same name, the initial file position specified for the last in the above sequence would be used.

All input/output files use a two record format for each array written. Routines READM and WRITEM are used to read and write these records.

READM/WRITEM FORMAT

Record 1 - ID Record	Word 1	- 5HMATIØ
	2	- MRØW = Row length of array
	3	- MCØL = Column length of array
	4	- LID = Length of user ID
	5-(4+LID)	- ID = User ID
Record 2 - ARRAY Record	Words	MRØW*MCØL - ARRAY, written (ARRAY(I,J),I=1,MRØW),J=1,MCØL)

3.5.2 C-Matrix Library

The C-matrix library, maintained on a user specified I/Ø file, CMFILE, consists of a two file set. File 1 consists of all saved C-matrices written sequentially in the order saved. File 2 consists of an index of File 1. If the user specifies a CMFILE, the index is examined for a match each time a C-matrix is required. If a match is found the desired C-matrix is accessed and used. If a match is not found, the desired C-matrix is calculated, the index updated, and the new C-matrix and updated index are written to CMFILE. If a legitimate index is not found on the first attempt to access information in an execution, the specified file is assumed to be a new file; an initial null index will be generated and execution will continue. There is no program limit on the number of C-matrices in the library.

All arrays on CMFILE are written and read using READM/WRITEM.

The CMFILE index consists of a list of entries associated with each C-matrix sufficient to allow testing for a match on a retrieval attempt. Note that the user must utilize MSID in input to deferentiate between main surface planforms, and CSID to deferentiate between control surfaces associated with a main surface planform. A main surface entry in the INDEX consists of 13 words, and contains a counter for the number of associated control surface entries which follow. A control surface entry

consists of one word; it can only be referenced through its associated main surface entry.

MAIN SURFACE ENTRY

WORD	BITS	VAR. TYPE	VARIABLE	DESCRIPTION
1	59-18	H	MSID	Main surface ID
	14-00	I	MATPØS	Position of matrix in file CMF1
2	35-30	I	SYM	Symmetry indicator
	29-24	I	NDWC	No. downwash chords
	23-18	I	NPDWC	No. points/downwash chord
	17-12	I	NSPT	No. spanwise main surface pressure terms
	11-6	I	NCPT	No. chordwise main surface pressure terms
	5-0	I	NCSE	Number of associated control surface entries
3		R	S	Semi-span
4		R	KVAL	ω/V - reduced frequency
5		R	MACH	M - mach number
6		H	DATE	Entry date
7-13		H	RTITLE	Entry run title

CONTROL SURFACE ENTRY

WORD	BITS	VAR. TYPE	VARIABLE	DESCRIPTION
1	59-18	H	CSID	Control surface ID
	17-15	I	CSTYPE	Control surface type Full span Tip span Mid span Partial span } Leading edge or Trailing edge
	14-00	I	MATPØS	Position of matrix in file CMF1

New main surface entries are appended to the bottom of the index. New control surface entries are inserted below the last previous control surface entry of its associated main surface entry.

3.5.3 File formats

All files, with the exception of INPUT and OUTPUT are described in this section; the order is alphabetical.

A file name, equivalent name, file type, and short description of usage are given in addition to record formats.

With respect to the headings, the following applies,

(1)	REC. NØ.	RECØRD NØ. OR IDENTIFIER
(2)	REPETITIØN	AN INTEGER SPECIFYING THE NUMBER OF IMMEDIATE REPETITIONS OF THE RECORD. REPETITIONS OF SETS OF RECORDS ARE DESCRIBED PRIOR TO THE SET.
(3)	VARIABLE	PROGRAM, INPUT, OR OUTPUT VARIABLE NAME.
	(DIMENSIONS)	NUMBER OF ELEMENTS ASSOCIATED WITH THE VARIABLE. NOTE THAT ALL ARRAYS ARE WRITTEN IN CDC6000 STORAGE ORDER, E.G., A(I,J,K) (((A(i,j,k),i=1,I),j=1,J),k=1,K)
(4)	T	TYPE OF INFORMATION I - INTEGER R - REAL C - COMPLEX (NO. TERMS=2*FIRST DIMENSION) H - HOLLERITH M - MIXED
(5)	DESCRIPTION	DESCRIPTION OF INFORMATION BY VARIABLE

The following variable names are used in describing DIMENSIONS.

1.	NØCS	NUMBER OF CONTROL SURFACES
2.	NØVP	NUMBER OF VELOCITY PROFILES
3.	NDWP	NUMBER OF DOWNWASH POINTS
4.	NPTRM	NUMBER OF ASSUMED MAIN SURFACE PRESSURE TERMS (=NSPT*NCPT, in most cases = NDWP)
5.	NDMDS	NUMBER OF DISPLACEMENT MODES
6.	NPMDS	NUMBER OF PRESSURE MODES (EITHER NDMDS OR NDMDS+1)
7.	NØKVAL	NUMBER OF REDUCED FREQUENCIES
8.	NØMACH	NUMBER OF MACH NUMBERS
9.	NØCØND	NUMBER OF CONDITIONS = NØKVAL*NØMACH
10.	NPRC	NUMBER OF PRESSURE REPORT CHORDS
11.	NPPRC	NUMBER OF POINTS/PRESSURE REPORT CHORD
12.	NPPT	NUMBER OF PRESSURE OUTPUT POINTS = NPRC*NPPRC
13.	NSGFC	NUMBER OF SECTIONAL FORCE OUTPUT CHORDS
14.	NPZØNE	NUMBER OF INPUT POINTS/MODAL INPUT ZONE
15.	LINDEX	LENGTH OF CMFILE INDEX

FILE NAME: CMFILE				FILE TYPE: SEQUENTIAL BINARY
CMFILE is a user specified INPUT/OUTPUT file generated and used by the RHOIV program as a library of previously calculated C-matrices. It is a multifile file; the first file is the set of all saved C-matrices, the second is an index of the first. Routines READM/WRITEM are used to READ/WRITE the file.				
REC. NO.	REPETITION	VARIABLE (DIMENSIONS)	T	DESCRIPTION
The record pair 1A,B is repeated NOCM times (refer to INDEX desc.).				
1A	1	READM/WRITEM ID INFO (4) USER ID (4) 1-8HC-MATRIX 2-S 3-KVAL 4-MACH	 H R R R	REFER TO PAGE 38 ARRAY NAME SEMI-SPAN REDUCED FREQUENCY=ω/V MACH NUMBER
1B	1	C (N,NDWP)	C	COMPLEX C-MATRIX, SAVED IN TRANSPOSE FORM. N=NPTRM FOR A MAIN SURFACE C-MATRIX, AND =4 FOR A CONTROL SURFACE C-MATRIX
2	1	END OF FILE		
3A	1	READM/WRITEM ID INFO (4) USER ID (5) 1-10HCMFL INDEX 2-NOCM 3-NMSNTRY 4-CDATE 5-LMDATE	 H I I H H	REFER TO PAGE 38 ARRAY NAME NUMBER OF C-MATRICES NUMBER OF MAIN SURFACE ENTRIES OR C-MATRICES LIBRARY CREATION DATE LAST MODIFICATION DATE
3B	1	INDEX (LINDEX)	M	CMFILE INDEX - REFER TO PAGE 38

FILE NAME: CMSFILE (= RHOSC2)			FILE TYPE: SEQUENTIAL BINARY	
CMSFILE is a sequential binary file used internally by RHOIV. It is generated by CMCALC and/or RDWRTC and used by PCMDWM and SCLUTON during the k-value, Mach no. condition cycle.				
REC. NO.	REPETITION	VARIABLE (DIMENSIONS)	T	DESCRIPTION
1	NDWP	ROWC (NPTRM)	C	ROW OF MAIN SURFACE PRESSURE TERM C-MATRIX
IF NOCS>0, a set of Rec. 2 is repeated per control, i.e. NOCS times.				
2	NDWP	ROWC (4)	C	ROW OF CONTROL SURFACE PRESSURE TERM C-MATRIX

FILE NAME: COFFILE (= RHOSC2)				FILE TYPE: SEQUENTIAL BINARY
COFFILE is a sequential binary file used internally by RHOIV. It is generated by SOLUTON and used by PCMSPT and the various result routines, FORMDP, FORMQS, and FORMQ, during the k-value Mach no. condition cycle.				
REC. NO.	REPETITION	VARIABLE (DIMENSIONS)	T	DESCRIPTION
1	NPMDS	CMSPT (NPTRM)	C	COEFFICIENTS OF MAIN SURFACE PRESSURE TERMS FOR A PRESSURE MODE

FILE NAME: DPFILE				FILE TYPE: SEQUENTIAL BINARY
DPFILE is a user specified output file which will contain any unsteady pressure results. Routine WRITEM is used to produce an ID record and record of values.				
REC. NO.	REPETITION	VARIABLE(DIMENSIONS)	T	DESCRIPTION
1A	1	READM/WRITEM ID INFO (4) USER ID (4) 1-10HRHOIV Y-DP 2-NPRC 3-NPPRC 4-NPPT	 H I I I	REFER TO PAGE 38 ARRAY NAME NUMBER OF PRESSURE REPORT CHORDS NO. POINTS/PRESSURE REPORT CHORD NO. PRESSURE POINTS
1B	1	YPRC(NPRC)	R	PRESSURE REPORT CHORDS
2A	1	READM/WRITEM ID INFO (4) USER ID (4) 1-10HRHOIV X-DP 2-NPRC 3-NPPRC 4-NPPT	I H I I I	REFER TO PAGE 38 AS ABOVE
2B	1	XPPT(NPPT)	R	PRESSURE REPORT POINTS
The record pair 3A,B is repeated per mode, i.e. NPMDS times, for each k-value, Mach no. condition. The record pair will occur a total of NOKVAL*NOMACH*NPMDS times.				
3A	1	READM/WRITEM ID INFO (4) USER ID (6) 1-8HRHOIV DP 2-RKVAL 3-B0 4-S 5-MACH 6-IMD	 H R R R R I	REFER TO PAGE 38 ARRAY NAME REF. K-VALUE= $b_0\omega/V$ K-VALUE REF. LENGTH SEMI-SPAN MACH NUMBER MODE NUMBER
3B	1	PRESS(NPPT)	C	COMPLEX PRESSURE AT OUTPUT POINTS FOR MODE IMD.

FILE NAME: GFFILE				FILE TYPE: SEQUENTIAL BINARY
GFFILE is a user specified output file which will contain any generalized force results. Routine WRITEM is used to produce an ID record and a record of values.				
REC. NO.	REPETITION	VARIABLE (DIMENSIONS)	T	DESCRIPTION
Record pair 1A,B are repeated per k-value, Mach number condition. The record pair will occur a total of NOKVAL*NOMACH times.				
1A	1	READM/WRITEM ID INFO (4) USER ID (5) 1-7HRHOIV Q 2-RKVAL 3-B0 4-S 5-MACH	M H R R R R	REFER TO PAGE 42 ARRAY NAME REFERENCE K-VALUE = bo ω/V K-VALUE REF. LENGTH SEMI-SPAN MACH NUMBER
1B	1	Q (NDMDS, NPMDS)	C	COMPLEX GENERALIZED FORCE MATRIX.

FILE NAME: INSFILE (= RHOSC2)				FILE TYPE: SEQUENTIAL BINARY
INSFILE is a sequential binary file used internally by RHOIV. It is generated by various input routines and used by the various preparation routines IIACAL, CRCOEFF, RESPREP, VPRDR.				
REC. NO.	REPETITION	VARIABLE (DIMENSIONS)	T	DESCRIPTION
Record set 1 occurs if NOVP>0, and is repeated NOVP times.				
1A	1	YVP NVPP	R I	STATION AT WHICH A VELOCITY PROFILE IS DEFINED NUMBER OF POINTS AT WHICH VELOCITY PROFILE IS SPECIFIED.
1B	1	XVP(NVPP) CVP(4,NVPP-1)	R R	VELOCITY PROFILE POINTS CUBIC COEFFICIENTS IN XVP DEFINING PROFILE
Record set 2 occurs if any pressure results have been requested, i.e. if DPPRT≠0, or DPFILE≠0.				
2A	1	YPRC(NPRC)	R	PRESSURE REPORT CHORDS
2B	1	XPPT(NPPT)	R	PRESSURE REPORT POINTS
Record set 3 occurs if any sectional force results have been requested, i.e. if SGFPRT≠0, or SGFFILE≠0.				
3	1	YSGFC(NSGFC)	R	SECTIONAL FORCE OUTPUT CHORDS
Record set 4 occurs unless IIAIN=.TRUE., i.e. unless interpolation information arrays have been input directly. The record set is repeated once for each input zone, i.e. NOCS+1 times.				
4A	1	NPZONE X(NPZONE) Y(NPZONE)	I R R	NUMBER OF INPUT POINTS IN ZONE X VALUES OF INPUT POINTS Y VALUES OF INPUT POINTS
4B	NDMDS	Z(NPZONE)	R	MODAL DISPLACEMENTS AT INPUT POINTS FOR ONE MODE

Record set 5 occurs if any user input of control rotation information has been indicated, i.e. NOCS>0 AND CRI(I)≠0 for some I=1,NOCS. The record set is repeated for each CRI(I)≠0.				
5	1	CCR(4,NDMDS)	R	CUBIC COEFFICIENTS OF CONTROL ROTATION OR $\Delta\partial Z/\partial x$ AT SPECIFIED HINGE POINTS

FILE NAME: MIFILE				FILE TYPE: SEQUENTIAL BINARY
MIFILE is a user specified input file which is used to provide modal input points and displacememts to RHOIV from disk or tape. Routine WRITEM or an equivalent should be used to generate the ID record and value record.				
REC. NO.	REPETITION	VARIABLE (DIMENSIONS)	T	DESCRIPTION
MIFILE may consist of either records 1A,B and 2A,B or 3A,B. If IIAIN=.T. in input, records 3A,B should be used. Otherwise use 1A,B,2A,B.				
The set 1A,B 2A,B may occur once or 1+NOCS times. In the latter case, assuming NOCS≠0, the modal input points and displacements are associated with the main surface, and control surfaces in the order defined in input.				
1A	1	READM/WRITEM ID INFO (4) USER ID (10)	M	REFER TO PAGE 38 A USER ID OF UP TO 10 WORDS MAY BE INCLUDED. THE ID IS NOT USED BY RHOIV.
1B	1	XY (NPZONE,2)	R	MODAL INPUT POINTS
2A	1	READM/WRITEM ID INFO (4) USER ID (10)	M	REFER TO PAGE 38 A USER ID OF UP TO 10 WORDS MAY BE INCLUDED. THE ID IS NOT USED BY RHOIV.
2B	1	Z (NPZONE,NDMDS)	R	MODAL DISPLACEMENTS AT INPUT POINTS
NOTE: If there is only one input zone, i.e. NOCS=0, or if points for all zones are being input in the same block, NPZONE should be the total number input points. Otherwise NPZONE should be the number of input points for the particular zone.				
Set 3A,B is used if IIAIN=.T., in which case the pair 3A,B should be repeated for each input zone, i.e 1+NOCS times.				
3A	1	READM/WRITEM ID INFO (4) USER ID (10)	M	REFER TO PAGE 38 A USER ID OF UP TO 10 WORDS MAY BE INCLUDED. THE ID IS NOT USED BY RHOIV.

3B	1	IIA(NIIA)	R	INTERPOLATION INFORMATION ARRAY, NIIA=NO. ELEMENTS IN ARRAY

FILE NAME: MISFILE (=RHOSC1)	FILE TYPE: SEQUENTIAL BINARY

MISFILE is a sequential binary file used internally by RHOIV. It is generated by MIINCK or IIACAL and read by IIARDR in the preparation prior to the k-value, Mach no. cycle.

MISFILE will be used if any modes exist.

REC. NO.	REPETITION	VARIABLE(DIMENSIONS)	T	DESCRIPTION
1	NOCS+1	NIIA IIA(NIIA)	I R	NUMBER OF IIA ELEMENTS INTERPOLATION INFOR. ARRAY FOR AN INPUT ZONE

<table>
<tr><td colspan="5">FILE NAME: RESFILE (=RHOSC1) FILE TYPE: SEQUENTIAL BINARY</td></tr>
<tr><td colspan="5">RESFILE is a sequential binary file used internally by RHOIV. It is generated by the various preparation routines, DWPREP, PRSPREP, SGFPREP, and GFPREP, prior to the k-value, Mach no. cycle, and used by the solution and result routines, PCMDWM, SOLUTON, FORMDP, FORMQS, and FORMQ, during the condition cycle.</td></tr>
<tr><th>REC. NO.</th><th>REPETITION</th><th>VARIABLE(DIMENSIONS)</th><th>T</th><th>DESCRIPTION</th></tr>
<tr><td>1A</td><td>NOCS
IF NOCS>0</td><td>CCR(4,NPMDS)</td><td>R</td><td>CUBIC COEFFICIENTS OF CONTROL ROTATION</td></tr>
<tr><td>1B</td><td>NPMDS</td><td>W(NDWP)</td><td>R</td><td>COLUMN OF THE BASIC DOWNWASH MATRIX</td></tr>
<tr><td colspan="5">Record set 2 occurs if any pressure results have been requested, i.e. if DPPRT≠0 or DPFILE≠0.</td></tr>
<tr><td>2A</td><td>1</td><td>YPRC(NPRC)</td><td>R</td><td>PRESSURE REPORT CHORDS</td></tr>
<tr><td>2B</td><td>1</td><td>XPPT(NPPT)</td><td>R</td><td>PRESSURE REPORT POINTS</td></tr>
<tr><td>2C</td><td>1</td><td>XBAR(NPPT)</td><td>R</td><td>NON-DIMENSIONAL (BAR NOTATION) REPR. OF PRESSURE REPORT POINTS</td></tr>
<tr><td>2D</td><td>1</td><td>MSPTRM(NPPT,NPTRM)</td><td>R</td><td>ASSUMED MAIN SURFACE PRESSURE TERMS EVAL. AT PRESSURE REPORT POINTS.</td></tr>
<tr><td>2E</td><td>NPMDS
IF NOCS>0</td><td>FETA(NPRC,NOCS)</td><td>R</td><td>ROTATION OF CONTROL SURFACES AT PRESSURE REPORT CHORDS FOR A MODE</td></tr>
<tr><td colspan="5">Record set 3 occurs if any sectional force results have been requested, i.e. if SGFPRT≠0 or SGFFILE≠0.</td></tr>
<tr><td>3A</td><td>1</td><td>YSGFC(NSGFC)</td><td>R</td><td>SECTIONAL FORCE OUTPUT CHORDS</td></tr>
<tr><td colspan="5">(1) The sequence 3B-3E is repeated per sectional force output chord, i.e. NSGFC times.</td></tr>
<tr><td>3B</td><td>1
REFER TO (1)</td><td>QSMSPT(NDMDS,NPTRM)</td><td>R</td><td>INTEGRALS OF ASSUMED MAIN SURFACE PRESSURE</td></tr>
</table>

3B CONT	↑			TERMS TIMES MODAL DISPLACEMENTS ALONG A SECTIONAL FORCE OUTPUT CHORD
(2) The sequence 3C-3E is repeated per control surface if NOCS>0.				
3C	1 REFER TO (1) AND (2)	NIPTS XIPT(NIPTS) QTYPE(NIPTS)	I R H	NUMBER OF QUADRATURE POINTS QUADRATURE POINTS QUADRATURE TYPE ASSOC. WITH QUADRATURE POINT
3D	1 REFER TO (1) AND (2)	FETA(NPMDS)	R	CONTROL ROTATIONS AT CHORD FOR ALL MODES
3E	NDMDS REFER TO (1) AND (2)	WZ(NIPTS)	R	QUADRATURE WEIGHTED DISPLACEMENTS AT XIPT FOR A MODE
Record set 4 occurs if any total generalized force results have been requested, i.e. if GFPRT≠0, or GFFILE≠0.				
4A	1	QMSPT(NDMDS,NPTRM)	R	SURFACE INTEGRALS OF MAIN SURFACE PRESSURE TERMS TIMES MODAL DISPLACEMENTS
4B	1 IF NOCS>0	NICHD YICHD(NICHD)	I R	NUMBER OF SPANWISE QUADRATURE CHORDS FOR SURFACE INTEGRATION QUADRATURE CHORDS
(3) The sequence 4C-4E is repeated once for each control (NOCS>0) by quadrature chord, i.e. NOCS*NICHD times.				
4C	1 REFER TO (3)	NIPTS XIPT(NIPTS) QTYPE(NIPTS)	I R I	NUMBER OF QUADRATURE POINTS QUADRATURE POINTS QUADRATURE TYPE ASSOC. WITH QUADRATURE POINTS
4D	1 REFER TO (3)	FETA(NPMDS)	R	CONTROL ROTATIONS AT A QUADRATURE CHORD
4E	NDMDS REFER TO (3)	WZ(NIPTS)	R	QUADRATURE WEIGHTED DISPLACEMENTS AT XIPT FOR A MODE

FILE NAME: SGFFILE				FILE TYPE: SEQUENTIAL BINARY
SGFFILE is a user specified output file which will contain any sectional force results. Routine READM is used to produce an ID record and a record of values.				
REC. NO.	REPETITION	VARIABLE (DIMENSIONS)	T	DESCRIPTION
1A	1	READM/WRITEM ID INFO (4) USER ID (2) 1 - 10HRHOIV Y-QS 2 - NSGFC	M H I	REFER TO PAGE 38 ARRAY NAME NO. SECTIONAL FORCE OUTPUT CHORDS
1B	1	YSGFC (NSGFC)	R	SECTIONAL FORCE OUTPUT CHORDS
The record pair 2A,B is repeated per sectional force output chord, i.e. NSGFC times for each k-value, Mach. no. condition. The record pair will occur a total of NOKVAL*NOMACH*NSGFC times.				
2A	1	READM/WRITEM ID INFO (4) USER ID (6) 1 - 8HRHOIV QS 2 - RKVAL 3 - B0 4 - S 5 - MACH 6 - ICHD	M H R R R R I	REFER TO PAGE 38 ARRAY NAME REFERENCE K-VALUE=$bo\omega/V$ K-VALUE REF. LENGTH SEMI-SPAN MACH NUMBER OUTPUT CHORD NUMBER
2B	1	QS (NDMDS,NPMDS)	C	COMPLEX SECTIONAL FORCE MATRIX FOR CHORD ICHD.

3.6 CONTROL CARDS

There are basically four modes of execution, from

a. source in source form;

b. source in UPDATE form;

c. relocatable binary;

d. absolute binary.

In the following, use of specific control cards has been avoided; rather the required sequence of operations is specified. All file names with the exception of RHOIV, are arbitrary. Note that all overlays have the name RHOIV, thus a file RHOIV is generated at load time. For the cases above

a. (1) Obtain a source file, PROG (2 records, from permanent storage (cards, tape, permanent disk file, etc.).

(2) Compile first record placing relocatable binary on BPROG.

(3) Compile second record placing relocatable binary on BSUBS.

(4) Generate an alternate library on SUBLIB from BSUBS.

(5) Load BPROG using alternate library SUBLIB.

(6) Execute from RHOIV.

*NOTE: On some systems, steps 4 and 5 of a. may be combined into one operation, e.g., loading BPROG using BSUBS directly as an alternate LIBRARY. On other systems in which the loader has no alternate library capability, a preload operation may be performed in which some program other than the loader searches for references in the routines in BPROG to routines in BSUBS generating a file LPROG, is then processed by the loader (i.e., the above program performs the alternate library function).

b. (1) Obtain an old program library file, OLDPL, from permanent storage.

(2) Using UPDATE generate a source file, PROG (2 records). (In UPDATE terminology, PROG would correspond to the COMPILE file.)

(3) Proceed with steps 2 - 6 of a.

c. (1) Obtain a relocatable binary file, BPROG, main routines, from permanent storage.

(2) Obtain a relocatable binary file, BSUBS, alternate library subroutines, from permanent storage.

(3) Proceed with steps 4 - 6 of a.

d. (1) Obtain an absolute binary file, RHOIV, from permanent storage.

(2) Execute from RHOIV.

3.7 PROGRAM INPUT

3.7.1 General Remarks

The input to RHOIV consists of both BCD input, e.g. cards, and binary, e.g. CMFILE or MIFILE. The card input includes planform description, definition of user I/O files, printed output specifications, list of k-values and Mach numbers and modal input description. Card input may also include velocity profile definitions, the distributions of downwash points, pressure output points, and sectional force output chords, and modal displacements with associated points. The binary input may consist of a library of C-matrices, and modal displacements with associated points or interpolation information arrays.

The card input consists of field dependent input and free field input. The field dependent input is identified in the field column of data stacking as a specific field (number) with associated format or as a LIST indicating sequential input per the FORMAT using as many cards as required. The free field input is identified by NAMELIST in the field column with associated list name in the FORMAT column. Some of the features of namelist input are:

(1) Card(s) field consist of columns 2 through 80,

(2) List consists of a $ list name in column 2 followed by a series of specifications continued on as many cards as required and terminated by a $.

(3) Specifications are of the form:

    a. Vname = Value

    b. Vname(1) = Value1, Value2,...,Valuen

Where Vname is one of the variable names for the list, value is the associated value(s). Value may be an integer, a floating point number in normal or exponential form, or in the case of a logical variable of the form.

.T. or .True. indicating true

.F. or .False. indicating false

(4) Specifications must be separated by commas. NOTE there is no comma between the last specification and terminating $.

(5) Embedded blanks are allowed except within the $ list name, variable name, or value. Note at least one blank must separate the $ list name and the first specification.

(6) The order of appearance of variables on the card(s) is not important - the spelling is.

(7) Any or all of the variables may be left out of the list, e.g., $list name .. $ is legitimate. This assumes of course that there is a legal default value associated with the variable(s) not included in the list.

There are a number of input sets consisting of x and y locations on the planform. Where feasible, the option of specifying this information in physical or local non-dimensional coordinates (bar notation) has been allowed.

3.7.2 Limitations

The following are size limitations within the program (also noted in Data Stacking):

$2 \le NLE \le 10$	No. leading edge definition points
$2 \le NTE \le 10$	No. trailing edge definition points
$0 \le NOCS \le 6$	No. control surfaces
$1 \le \lvert NDWC \rvert \le N$	No. downwash chords, $N = 72 / \lvert NPDWC \rvert$
$1 \le \lvert NPDWC \rvert \le 8$	No. Pts. per downwash chord
$1 \le NOKVAL \le 20$	No. reduced frequencies
$1 \le NOMACH \le 20$	No. mach numbers

The following are analysis limitations:

No downwash chord should be placed at the tip or control surface side edge. In general downwash chords should satisfy $|y-\eta_s| \ge .02S$ where η_s is the tip or a control side edge.

It is not recommended that a downwash chord be placed at or near a spanwise planform discontinuity, e.g., a change in leading edge or trailing edge slope.

No downwash point should be placed at the leading edge, trailing edge, or control surface hinge.

The downwash point distribution should be such that the boundary conditions are sufficiently defined. (A downwash point on a control surface is not specifically required.)

No pressure report chord or sectional generalized force report chord should be placed at a control surface side edge.

No pressure report point should be placed on a control surface hinge.

DATA INPUT FLOW

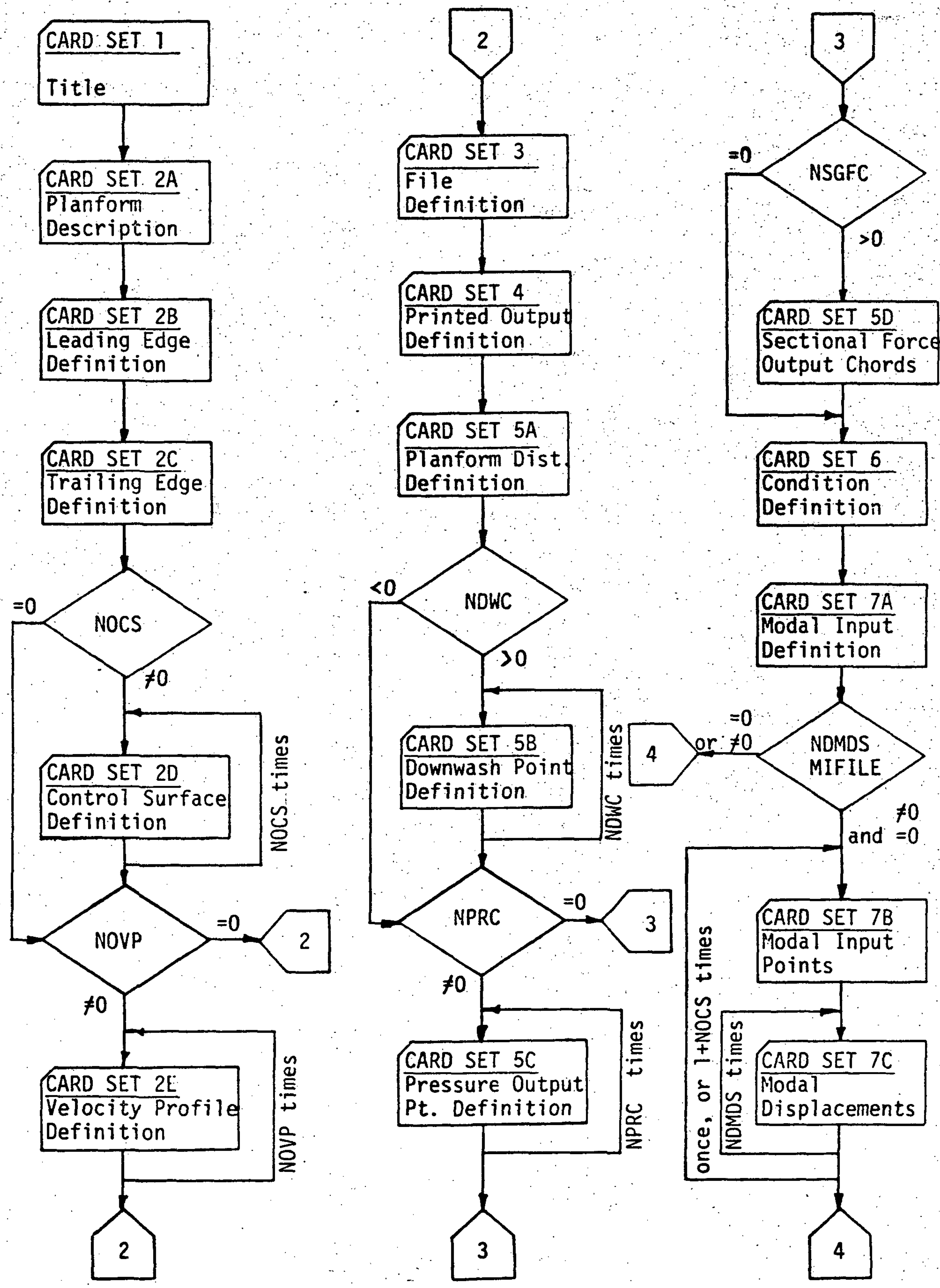


FIGURE 2

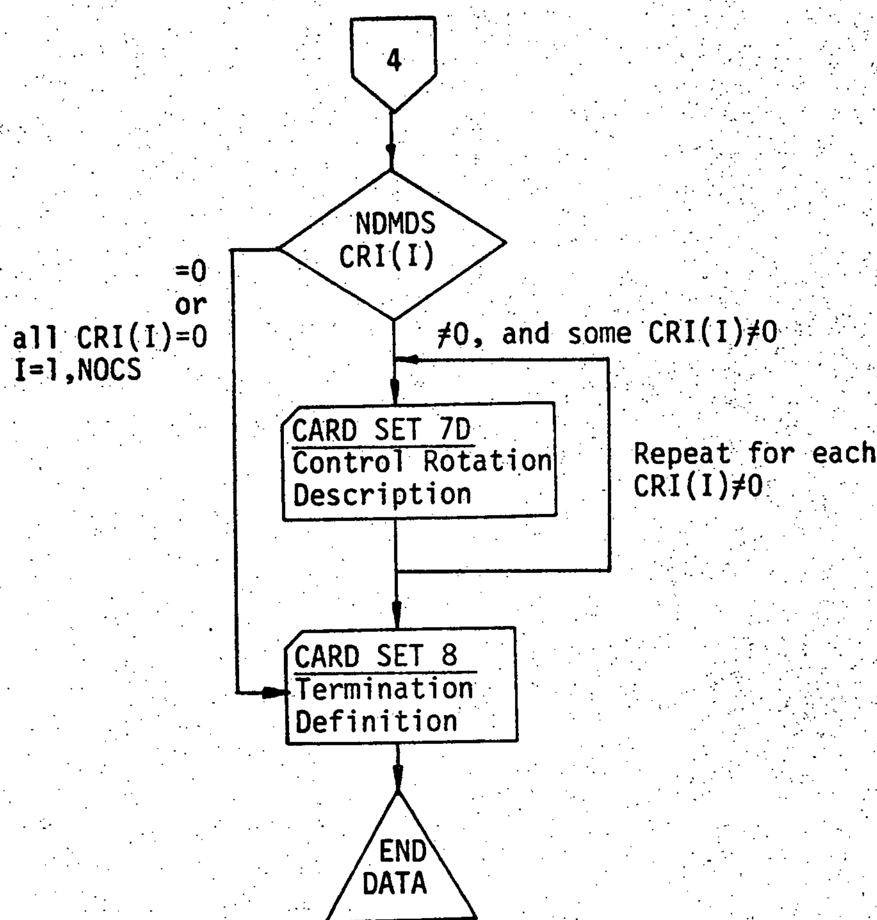


FIGURE 2 (continued)

RHOIV COSINE DISTRIBUTIONS

N	Distribution of chords - $\eta = \cos\{i\pi/(2N+1)\}$, $i = 1, N$								
1	.5000								
2	.8090	.3090							
3	.9010	.6235	.2225						
4	.9397	.7660	.5000	.1736					
5	.9595	.8413	.6549	.4154	.1423				
6	.9709	.8855	.7485	.5681	.3546	.1205			
7	.9781	.9135	.8090	.6691	.5000	.3090	.1045		
8	.9830	.9325	.8502	.7390	.6025	.4457	.2737	.0923	
9	.9864	.9458	.8795	.7891	.6773	.5469	.4017	.2455	.0826

N	Distribution of points/chord - $\xi = -\cos\{2i\pi/(2N+1)\}$, $i = 1, N$							
1	.5000							
2	-.3090	.8090						
3	-.6235	.2225	.9010					
4	-.7660	-.1736	.5000	.9397				
5	-.8413	-.4154	.1423	.6549	.9595			
6	-.8855	-.5681	-.1205	.3546	.7485	.9709		
7	-.9135	-.6691	-.3090	.1045	.5000	.8090	.9781	
8	-.9325	-.7390	-.4457	-.0923	.2737	.6026	.8502	.9830

NOTE: %Chord/100 = $\xi/2 + .5$

FIGURE 3

3.7.3 DATA STACKING

CARD SET	FIELD NO.	COLUMNS	FORMAT	VARIABLE	DESCRIPTION

(1) TITLE

CARD SET	FIELD NO.	COLUMNS	FORMAT	VARIABLE	DESCRIPTION
1	1	1-70	7A10	RTITLE	RUN TITLE - OUTPUT HEADER

(2) PLANFORM DEFINITION

CARD SET	FIELD NO. / COLUMNS	FORMAT	VARIABLE	DESCRIPTION
2A	RHOA	NAMELIST	NLE	Number of leading edge defn. pts. 2≤NLE≤10 (No Default)
			NTE	Number of trailing edge defn. pts. 2≤NTE≤10 (No Default)
			NCOS	Number of control surfaces 0≤NOCS≤6 (Default is 0)
			NOVP	Number of velocity profiles 0≤NOVP (Default is 0)
			MSID	A unique identifier which will be associated with any main surface C-matrix generated 1-5 digit integer (Default is 0)
			SYM	Symmetry Indicator 0 - Symmetric (default) 1 - Antisymmetric
			BO	k-value reference length BO > 0 (Default is root semi-chord as determined from XLE(1),XTE(1)
			S	Semi-span, S> 0 (Default is YLE(NLE)-YLE(1))
2B	LIST	6F10.0	XLE(I) YLE(I)	NLE pairs of X,Y values Defining the planform leading edge YLE(I+1)>YLE(I)
2C	LIST	6F10.0	XTE(I) YTE(I)	NTE pairs of X,Y values defining the planform trailing edge YTE(I+1)>(YTE(I), YTE(1) = YLE(1)

CARD SET	FIELD NO.	COLUMNS	FORMAT	VARIABLE	DESCRIPTION

(2) PLANFORM DEFINITION (Continued)

If NOCS > 0, repeat set 2D NOCS times; otherwise, omit 2D.

CARD SET	FIELD NO.	COLUMNS	FORMAT	VARIABLE	DESCRIPTION
2D	1	1-10	A7,3X	CSID	An identifier to be associated with a control surface C-matrix.
	2	11-20	F10.0	XHLI	X value of inboard hinge point
	3	21-30	F10.0	YHLI	Inboard control side edge.
	4	31-40	F10.0	XHLO	X value of outboard hinge point.
	5	41-50	F10.0	YHLO	Outboard control side edge.
	6	51-60	F10.0	LEIND	Leading edge control indicator ≠0 - leading edge, =0 - trailing edge (Default is 0).

If NOVP>0, repeat sets 2E and F NOVP times; otherwise omit 2E, F. Note if NOVP>1, YVP values must be strictly increasing.

CARD SET	FIELD NO.	COLUMNS	FORMAT	VARIABLE	DESCRIPTION
2E	1	1-10	F10.0	YVP	Station at which velocity profile is specified. If NOVP=1, any value may be used (e.g., 0).
	2	11-20	I10	NVPP	Number of points defining velocity profile at YVP. (NVPP≥2)
2F	LIST		6F10.0	XVP(I) VP(I)	NVPP pairs of values XVP = fraction of chord VP = velocity profile value XVP(I)<XVP(I+1) XVP(1)≤0. XVP(NVPP)≥1.0

(3) FILE DEFINITION

CARD SET	FIELD NO.	COLUMNS	FORMAT	VARIABLE	DESCRIPTION
3	RHOB		NAMELIST		Default for all filenames is 0 File name in the form = n, (1≤n≤5)
				MIFILE	Modal input file name
				CMFILE	C-matrix file name

CARD SET	FIELD NO. / COLUMNS	FORMAT	VARIABLE	DESCRIPTION
			DPFILE	Delta pressure file name
			SGFFILE	Sect. gen. force file name
			GFFILE	Generalized force file name
				Default for all file initial positions is 1
			MIF1	Initial file position of MIFILE
			CMF1	Initial file position of CMFILE
			DPF1	Initial file position of DPFILE
			SGFF1	Initial file position of SGFFILE
			GFF1	Initial file position of GFFILE
				Note that CMFILE must be discrete; the others may be discrete or the same. If any of DPFILE, SGFFILE or GFFILE are the same, note that files are positioned in the order. DPFILE/DPF1, SGFFILE/SGF1, and GFFILE/GFF1

(4) PRINTED OUTPUT DEFINITION

4	RHOC	NAMELIST		The default for all output control is 0. The input may be of form n<0 - print for all conditions =0 - no print-out n>0 - print for first n conditions
			DPPRT	Delta pressure print control
			SGFPRT	Sectional gen. force print control
			GFPRT	Generalized force print control

CARD SET	FIELD NO. COLUMNS	FORMAT	VARIABLE	DESCRIPTION
			DWMPRT CMPRT PCMPRT	Downwash matrix print control C-matrix print control Pressure coefficient matrix print control

(5) PLANFORM DISTRIBUTIONS

CARD SET	FIELD NO. COLUMNS	FORMAT	VARIABLE	DESCRIPTION
5A	RHOD	NAMELIST	NDWC	Number of downwash chords $0<\|NDWC\|*\|NPDWC\|\leq 72$ (No Default) If NDWC<0, a default cosine distribution will be generated. $YDWC(I)=COS(i\pi/(2NDWC+1))$ $XPWD(I)=-COS(2i\pi/(2NPDWC+1))$
			NPDWC	Number of points per downwash chord. $0<\|NPDWC\|\leq 8$ (No default) If NPDWC<0, the user input in set 5B is assumed to be in local non-dimensional coordinates (BAR notation)
			NPRC (1)	Number of pressure output chords. If NPRC <0, the user input in set 5C is assumed to be in local non-dimensional coordinates
			NPPRC	Number of points per pressure output chord.

(1) If no user output chords are specified, but printed output or file output is indicated, a default set of 11 output chords (and for pressure, 21 output points/chord) is used ($\underline{\eta}$ = .01,.1,.2,...,.8,.9,.99),($\underline{\xi}$ = -.99,-.9,-.8,...,.8, .9,.99).

CARD SET	FIELD NO. COLUMNS	FORMAT	VARIABLE	DESCRIPTION
			NSGFC (1)	Number of sectional force output chords. If NSGFC<0, the user input in set 5D is assumed to be in non-dimensional coordinates.

CARD SET	FIELD NO.	COLUMNS	FORMAT	VARIABLE	DESCRIPTION
If NDWC<0, omit set 5B. The specified default cosine distributions will be used. Otherwise, repeat set 5B NDWC times. Note that input in 5B should be in physical coordinates if NPDWC>0, and in local non-dimensional coordinates if NPDWC<0.					
5B	1	1-10	F10.0	YDWC	Y or $\underline{Y}$ of downwash chord
	LIST		6F10.0 (7F10.0)	XDWP(I)	X or $\underline{X}$ of points on downwash chord I=1,NPDWC
If NPRC=0, omit set 5C; otherwise, repeat set 5C NPRC times. Note that input in 5C should be in physical coordinates if NPRC > 0, and in local non-dimensional coordinates if NPRC < 0.					
5C	1	1-10	F10.0	YPRC	Y or $\underline{Y}$ pressure output chord
	LIST		6F10.0 (7F10.0)	XPPT(I)	X or $\underline{X}$ points on pressure output chord. I=1,NPPRC
If NSGFC=0, omit set 5D. Note that input in 5D should be in physical coordinates if NSGFC>0, and in local non-dimensional coordinates if NSGFC<0.					
5D	LIST		7F10.0	YSGFC(I)	Y or $\underline{Y}$ of sectional force output chords. I=1,NSGFC

(6) CONDITION DEFINITION

6	RHOE	NAMELIST	KVALUE	List of reduced frequencies, (k≤0)
			MACHNØ	List of Mach numbers (0≤M<1.0) Both items must have at least one value, and may have up to 20 values.

(7) MODAL INPUT DEFINITION

7A	RHOF	NAMELIST	NIPTS(I)	Number of modal input points/ input zone NIPTS(I)≥3, I=1, NOCS+1. Alternatively, for

CARD SET	FIELD NO. / COLUMNS	FORMAT	VARIABLE	DESCRIPTION
				NOCS≠0, all input points may be input in a single block, in which case the program will determine which input points lie in which input zone.
7A (cont.)			NDMDS	Number of displacement modes
			ZF	A user supplied multiplicative factor which will be applied to modes input in card set 7C. (Default is 1.0)
			CRI(I)	Control rotation input indicator n<0, Delta $\partial Z/\partial X$ will be specified at required hinge points n=0, no input n>0, Cubic coefficients of control rotation will be specified (Default is 0 for all I) I=1,NOCS
			DGUST	Discrete gust option (Default = .F.) DGUST = .T. will cause a discrete gust mode to be appended to the set of displacement modes.
			GPGUST	Gradual penetration gust option (Default=.F.) GPGUST=.T. will cause a gradual penetration gust mode to be appended to the set of displacement modes.
			GPGREF	Gradual penetration gust reference (zero phase) point. (Default = 0)

If MIFILE≠0, i.e., if modal input is to be read from MIFILE, or if NDMDS=0, omit sets 7B and C. Otherwise, repeat sets 7B and C once or once per each input zone, i.e., either 1 or NOCS+1 times.

CARD SET	FIELD NO. COLUMNS	FORMAT	VARIABLE	DESCRIPTION
7B	LIST	6F10.0	X(I),Y(I)	Modal input points, I=1,NIPTS note (X(I),Y(I)) ≠ (X(J),Y(J)) for I≠J
Repeat set 7C once for each displacement mode, i.e, NDMDS times.				
7C	LIST	7F10.0	Z(I)	Modal displacement at point (X(I),Y(I)),I=1,NIPTS
If any CRI(I)≠0, repeat set 7D once for each CRI(I)≠0.				
7D	RHOG	NAMELIST	CCR(I,J)	Cubic coefficients of control rotation (Default = 0) I=1,4; 1-C_0, 2-C_1, 3-C_2, 4-C_3 J=1,NDMDS Only those terms which are non-zero need be input
			or DZDX(I,J)	Delta DZ/DX at control hinge equation points, I=1,4. ($\underline{\eta}_{cs}$ = 0,1/3,2/3,1) J=1,NDMDS

(8) TERMINATION DEFINITION

8	1	1-7	A7,3X	LNAME	Termination indicator Blank / "EXIT" — CALL EXIT "RETURN" — execute return to calling overlay Anything else, execute CALL OVERLAY (LNAME,L1,L2,0)
	2	11-20	I10	L1	Primary level overlay no.
	3	21-30	I10	L2	Secondary level overlay no.

3.8 PROGRAM OUTPUT

3.8.1 Program Results

Printed output of program results consists of an initial block of information reflecting the user's input, followed by those intermediate and final results specified in card set 4, Printed Output Definition. The output controlled by card set 4 is calculated for each k-value Mach number condition; the user may elect to have all, none, or some first n conditions printed.

The intermediate output consists of downwash matrices, C-matrices, and coefficients of assumed main surface pressure terms. If C-matrix printout is specified and control surfaces exist, the C-matrices for all controls as well as the main surface pressure terms are printed. If downwash matrix printout is specified and control surfaces exist, the residual downwash as well as full downwash will be printed. Note that the output of full and residual downwash is cyclic, four modes at a time.

The final results consist of unsteady pressures, sectional and total generalized forces. Generalized force output consists of a single matrix per condition. Sectional force output consists of a matrix per sectional force chord (in the order specified) per condition. Unsteady pressure output consists of real/imaginary and amplitude/phase per output point (in the order specified) written two modes at a time for all pressure modes per condition.

Following all condition output, a summary of the CMFILE index is given if CMFILE is present. Finally a summary of maximum core required and central processor time used is given.

All normal output includes the user's run title with date appended and k-value and Mach number identified (if applicable).

Binary output from the program consists of all unsteady pressure results if DPFILE≠0, all sectional force results if SGFFILE≠0, and all generalized force results if GFFILE≠0. The form of the information is described in section 3.5(Note that a user may have all binary output placed on the same file, in which case the results are interspersed on a condition basis).

3.8.2 Program Diagnostics

Program diagnostics may occur during input preparation or execution of the problem. The RHOIV input processor attempts to read and check all user input, identifying as many data errors as possible. If any errors are discovered during input processing

the execution is terminated following input. Errors which may be discovered include:

(1) exceedance of program size restrictions,

(2) illegal planform definition,

(3) illegal distribution of points on the planform,

(4) inaccurate file specifications,

(5) illegal k-values or Mach numbers,

(6) insufficient modal input definition.

With one specific exception, if a user's input is processed with no errors, and sufficient memory allocation is provided, the job should be completed without user origin errors. If any errors do occur they should be of program or system origin.

The exception to the above can occur during C-matrix calculations. If a downwash chord is placed too close to the planform tip or a control surface side edge, the chordwise integration grid routine CGRID may generate an illegal sequence of integration regions. If the condition $\varepsilon = 3.76|Y_0|/S<.001$ occurs a warning message will be printed to indicate a possible problem may occur for a particular integration chord. The condition will occur anytime a downwash chord is less than .02S from the tip or a control side edge.

The message does not indicate an error, only the fact that the above condition has not been met.

The following is a list of input processor diagnostics; the input numbers used are examples,

<u>PLANFORM DEFINITION ERROR</u>:

1. Illegal no. leading edge defn. pts. $(2 \le NLE \le 10)$,NLE = 11

2. Illegal no. trailing edge defn. pts. $(2 \le NTE \le 10)$,NTE = 11

3. Illegal no. control surfaces $(0 \le NOCS \le 6)$,NOCS = 7

4. Illegal no. velocity profiles $(0 \le NOVP)$,NOVP = -1

5. YLE(1) $\neq$ YTE(1)

6. YLE(NLE) $\neq$ YTE(NTE)

7. Illegal leading edge definition, YLE not strictly increasing

8. Illegal trailing edge definition, YTE not strictly increasing

9. Leading edge and trailing edge intersect

10. Control surface 1 does not lie within defined planform

11. Control surface 2 and 1 are incompatible

12. Velocity profile stations are not strictly increasing

13. Illegal no. of velocity profile pcints for station 1 (2<NVPP),NVPP = -1

14. Velocity profile points, XVP, for station 1 are not strictly increasing

15. *** SCAMP4 *** error *** on velocity station 1 non user error

FILE DEFINITION ERROR:

1. File spacing error 4, encountered for initial position of DPFILE

2. CMFILE name is not descrete

PLANFORM DISTRIBUTION ERROR:

1. Illegal no. downwash chords, (1≤ABS(NDWC*NPDWC)≤72), NDWC = -10

2. Illegal no. points/downwash chord, (1≤ABS(NPDWC)≤8),NPDWC = 10

3. Downwash point 1, not on defined planform

4. Downwash chord 1, coincides with a control surface side edge

5. Downwash point 2, coincides with a control surface hinge

6. Downwash points no. 2 and no. 1, are coincident

7. Pressure report chord 1, not on defined planform

8. Pressure report point for chord no. 1, not on planform

9. Pressure report point 1, coincides with a control hinge

10. Pressure report chord 1, coincides with a control side edge

11. Sectional force report chord 1, not on defined planform

12. Sectional force report chord 1, coincides with a control side edge

<u>CONDITION DEFINITION ERROR</u>:

1. Illegal no. k-values, $(0 < \text{no.KVAL})$

2. Illegal no. Mach nos., $(0 < \text{no. MACH})$

3. Illegal k-value, $(0 \leq \text{KVAL})$

4. Illegal Mach no., $(0 \leq \text{MACH} < 1.0)$

<u>MODAL INPUT DEFINITION ERROR</u>:

1. Illegal no. displacement modes, $(0 \leq \text{NDMDS})$, NDMDS = -3

2. Illegal no. input points, $(3 \leq \text{NIPTS})$, NIPTS=2

3. Insufficient input pts. in zone 1. $(3 \leq \text{NPZONE})$, NPZONE = 2

4. Input pts. no. 2 and no. 3, are coincident

5. File spacing error 1, on MIFILE

6. I/O error MROW<MROWS on MIFILE while reading X,Y for zone 1

7. I/O error MROW<MROWD on MIFILE while reading Z for zone 1

8. I/O error MROW<MROWD on MIFILE while reading IIA for zone 1

3.9 SAMPLE INPUT/OUTPUT

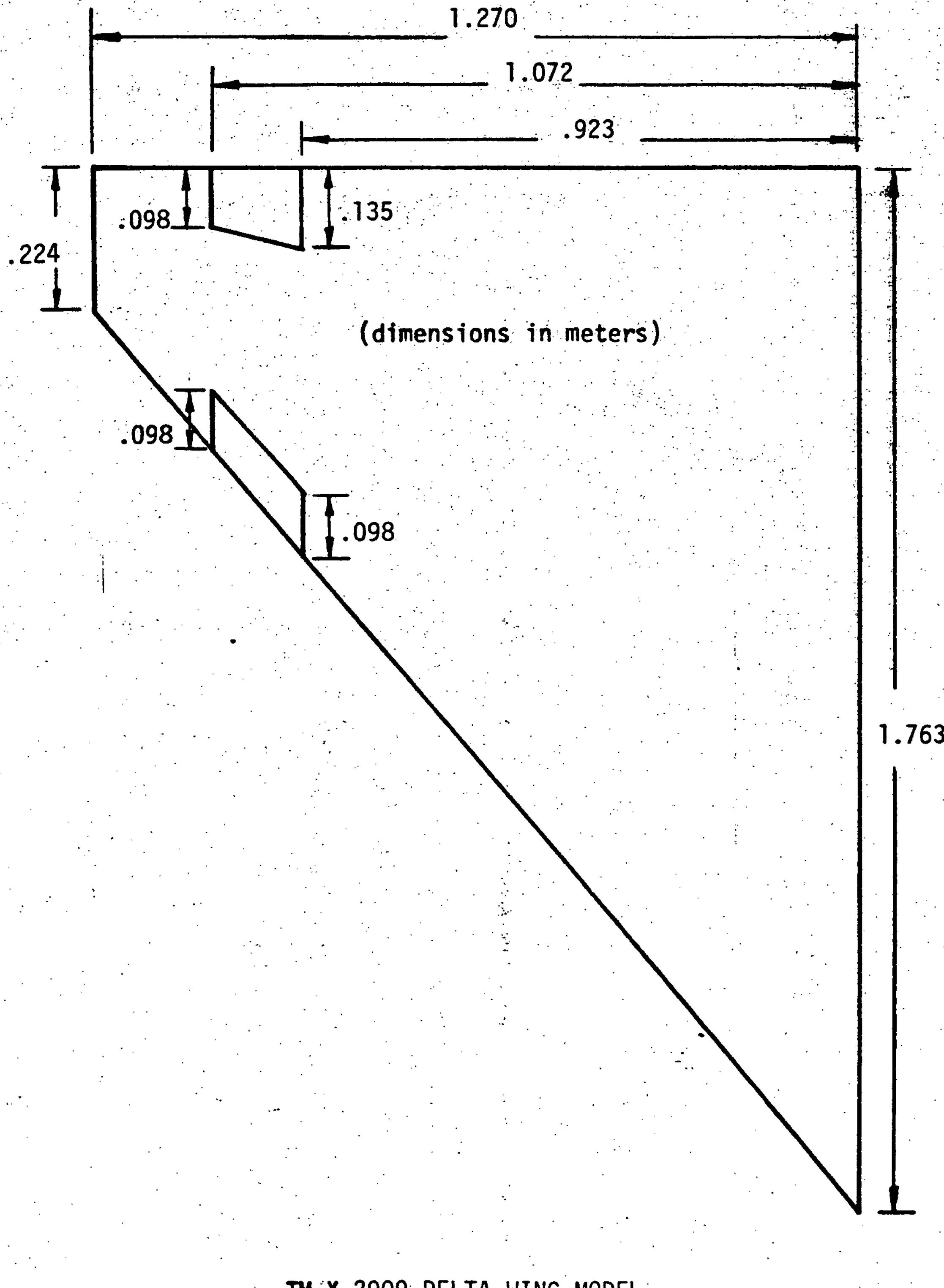
The following input data, figure 4, is for the lifting surface shown in figure 5, page 76. A portion of the output generated by this data case is given on pages 77-100.

RHOIV SAMPLE DATA INPUT

```
CARD                        COLUMNS
SET  1          11         21         31         41         51         61

1    NASA TM X-2909 leading/trailing edge controls
2A    $RHOA MSID=7000, NLE=2, NTE=2, NOCS=2, NOVP=1 $
2B   0.0        0.0        1.539      1.270
2C   1.763      0.0        1.763      1.270
2D   LECS       1.2165     .923       1.072      1.0
     TECS       1.628      .923       1.665      1.072
2E   0.0                  41
2F   0.0        .8         .005       .86818     .011       .95
     .015       .965       .02        .97        .025       .9746
     .0375      .9819      .05        .9877      .0625      .992
     .9875      1.0001     .1125      1.0065     .1375      1.0017
     .1625      1.0161     .1875      1.0199     .2125      1.0231
     .2625      1.0281     .3125      1.0321     .3625      1.0349
     .4125      1.0367     .4625      1.0377     .5125      1.0379
     .5625      1.0373     .6125      1.0359     .6625      1.0336
     .7125      1.0303     .7625      1.0259     .7875      1.0231
     .8125      1.0199     .8375      1.0161     .8625      1.0117
     .8875      1.0065     .9125      1.0001     .9375      .992
     .95        .9877      .9625      .9819      .975       .9746
     .98        .97        .985       .965       .989       .95
     .995       .86818     1.         .8
3     $RHOB CMFILE=1 $
4     $RHOC DPPRT=-1,CMPRT=-1,DWMPRT=-1,PCMPRT=-1,SGFPRT=-1,GFPRT=-1 $
5A    $RHOD NDWC=-9, NPDWC=7 $
6     $RHOE KVALUE(1)=0., MACHNO(1)=0.8 $
7A    $RHOF NIPTS(1)7, NDMDS=5 $
7B   0.0        0.0        1.212      1.0        1.2165     .923
     1.3971     1.071      2.628      .923       1.665      1.072
     1.763      1.0
7C   1.         1.         1.         1.         1.         1.         1.
     .8815      -.3305     -.335      -.5156     -.7465     -.7835     -.8815
     0.         .098       0.         0.         0.         0.         0.
     0.         0.         0.         0.         0.         0.         -.1158792
     0.         .098       0.         0.         0.         0.         -.1158792
8    EXIT
```

FIGURE 4



TM X-2909 DELTA WING MODEL

FIGURE 5

```
RHOIV  UNSTEADY  AERODYNAMICS
-----  --------  ------------

DATE - APR 12, 1975                  VERSION - MAY 1, 1975

CALCULATE UNSTEADY LOADINGS CAUSED BY MOTIONS OF A LIFTING
SURFACE WITH LEADING AND/OR TRAILING EDGE, SEALED GAP
CONTROLS IN COMPRESSIBLE SUBSONIC FLOW

PREPARED UNDER N.A.S.A. CONTRACT NO. NAS1-12020,
LANGLEY RESEARCH CENTER

1. T I T L E
   ---------

   N A S A   T M   X - 2 9 0 9   LEADING/TRAILING EDGE CONTROLS

2. P L A N F O R M   D E F I N I T I O N
   ---------------   ---------------------

  (A)  NLE =    2      NO. LEADING EDGE DEFINITION POINTS
       NTE =    2      NO. TRAILING EDGE DEFINITION POINTS
      NOCS =    2      NO. CONTROL SURFACES
      NOVP =    1      NO. VELOCITY PROFILES
      MSID = 7000      MAIN SURFACE C-MATRIX ID
       SYM =    0      SYMMETRY (0-SYMMETRIC,#0-ANTISYMMETRIC)
        B0 =    .0000  REDUCED FREQUENCY REFERENCE LENGTH
                       (DEFAULT VALUE(S) WILL BE GENERATED)
         S =    .0000  PLANFORM SEMI-SPAN
                       (DEFAULT VALUE(S) WILL BE GENERATED)

  (B) LEADING EDGE DEFINITION POINTS
      XLE =      .0000     1.5390
      YLE =      .0000     1.2700

  (C) TRAILING EDGE DEFINITION POINTS
      XTE =     1.7630     1.7630
      YTE =      .0000     1.2700

 ------- B0 =    .8815 GENERATED REDUCED FREQ. REF. LENGTH

 -------  S =   1.2700 GENERATED PLANFORM SEMI-SPAN

  (D) CONTROL SURFACE DEFINITION
      NO. TYPE   CSID      XHLI       YHLI       XHLO       YHLO
      --- ----  ------  ---------  ---------  ---------  ---------
       1 L.E.  LECS       1.2165      .9230     1.3971     1.0720
       2 T.E.  TECS       1.6280      .9230     1.6650     1.0720

  (E,F) VELOCITY PROFILE DEFINITION
        1 YVP =     .0000   NVPP =   41
          XVP =  .0000  .0050  .0110  .0150  .0200  .0250  .0375  .0500  .0625  .0875  .1125  .1375  .1625  .1875  .2125  .2625
                 .3125  .3625  .4125  .4625  .5125  .5625  .6125  .6625  .7125  .7625  .7875  .8125  .8375  .8625  .8875  .9125
                 .9375  .9500  .9625  .9750  .9800  .9850  .9890  .9950 1.0000
```

```
VP =  .8000  .8682  .9500  .9650  .9700  .9746  .9819  .9877  .9920 1.0001 1.0065 1.0117 1.0161 1.0199 1.0231 1.0281
     1.0321 1.0349 1.0367 1.0377 1.0379 1.0373 1.0359 1.0336 1.0303 1.0259 1.0231 1.0199 1.0161 1.0117 1.0065 1.0001
      .9920  .9877  .9819  .9746  .9700  .9650  .9500  .8682  .8000

3. F I L E   D E F I N I T I O N

   CMFILE = TAPE1      C-MATRIX I/O FILE NAME
   MIFILE =            MODAL INPUT FILE NAME
   DPFILE =            PRESSURE OUTPUT FILE NAME
  SGFFILE =            SECT. GEN. FORCE OUTPUT FILE NAME
   GFFILE =            GENERALIZED FORCE OUTPUT FILE NAME

     CMFI =   1        CMFILE  INITIAL FILE POSITION
     MIFI =   1        MIFILE  INITIAL FILE POSITION
     DPFI =   1        DPFILE  INITIAL FILE POSITION
    SGFFI =   1        SGFFILE INITIAL FILE POSITION
     GFFI =   1        GFFILE  INITIAL FILE POSITION

4. P R I N T E D   O U T P U T   D E F I N I T I O N

    DPPRT =  -1        PRESSURE REPORT PRINT CONTROL
   SGFPRT =  -1        SECT. GEN. FORCE PRINT CONTROL
    GFPRT =  -1        GENERALIZED FORCE PRINT CONTROL

    CMPRT =  -1        C-MATRIX PRINT CONTROL
   DWMPRT =  -1        DOWNWASH MATRIX PRINT CONTROL
   PCMPRT =  -1        PRESSURE COEFFICIENT MATRIX PRINT CONTROL

5. P L A N F O R M   D I S T R I B U T I O N S

 (A) NDWC =  12        NUMBER OF DOWNWASH CHORDS
                       (BAR NOTATION INPUT)
    NPDWC =  -6        NUMBER OF POINTS PER DOWNWASH CHORD
     NPRC =   0        NUMBER OF PRESSURE REPORT CHORDS
                       (DEFAULT VALUE(S) WILL BE GENERATED)
    NPPRC =   0        NUMBER OF POINTS PER PRESSURE REPORT CHORD
    NSGFC =   0        NUMBER OF SECT. GEN. FORCE OUTPUT CHORDS
                       (DEFAULT VALUE(S) WILL BE GENERATED)

 (B) DOWNWASH POINT DEFINITION
```

NO.	YDWC	X-PT. 1	X-PT. 2	X-PT. 3	X-PT. 4	X-PT. 5	X-PT. 6
1	.1143	.2315	.4893	.8529	1.2388	1.5587	1.6882
2	.2667	.4056	.6341	.9563	1.2984	1.5819	1.6967
3	.4064	.5652	.7668	1.0512	1.3530	1.6032	1.7045
4	.5398	.7176	.8935	1.1417	1.4051	1.6236	1.7119
5	.6604	.8554	1.0082	1.2236	1.4523	1.6419	1.7187
6	.7696	.9802	1.1120	1.2978	1.4950	1.6586	1.7248
7	.8649	1.0890	1.2025	1.3625	1.5323	1.6731	1.7301
8	.9525	1.1891	1.2857	1.4219	1.5666	1.6864	1.7350

9	1.0350	1.2834	1.3641	1.4780	1.5988	1.6990	1.7396
10	1.1240	1.3850	1.4486	1.5383	1.6336	1.7126	1.7445
11	1.2002	1.4720	1.5210	1.5901	1.6634	1.7242	1.7488
12	1.2522	1.5315	1.5705	1.6254	1.6838	1.7321	1.7517

(C) PRESSURE REPORT POINT DEFINITION

NO.	YPRC										
1	.0127	.0241	.1028	.1902	.2775	.3649	.4523	.5397	.6271	.7144	.8018
		.8892	.9766	1.0640	1.1513	1.2387	1.3261	1.4135	1.5009	1.5882	1.6756
		1.7543									
2	.1270	.1619	.2344	.3148	.3953	.4757	.5562	.6366	.7171	.7975	.8780
		.9585	1.0389	1.1194	1.1998	1.2803	1.3607	1.4412	1.5216	1.6021	1.6825
		1.7550									
3	.2540	.3151	.3806	.4533	.5261	.5988	.6716	.7444	.8171	.8899	.9626
		1.0354	1.1082	1.1809	1.2537	1.3264	1.3992	1.4720	1.5447	1.6175	1.6902
		1.7557									
4	.3810	.4682	.5268	.5918	.6569	.7220	.7870	.8521	.9172	.9822	1.0473
		1.1123	1.1774	1.2425	1.3075	1.3726	1.4377	1.5027	1.5678	1.6329	1.6979
		1.7565									
5	.5080	.6213	.6730	.7303	.7877	.8451	.9025	.9598	1.0172	1.0746	1.1319
		1.1893	1.2467	1.3040	1.3614	1.4188	1.4761	1.5335	1.5909	1.6483	1.7056
		1.7573									
6	.6350	.7745	.8192	.8689	.9185	.9682	1.0179	1.0675	1.1172	1.1669	1.2166
		1.2662	1.3159	1.3656	1.4153	1.4649	1.5146	1.5643	1.6140	1.6636	1.7133
		1.7580									
7	.7620	.9276	.9654	1.0074	1.0493	1.0913	1.1333	1.1753	1.2173	1.2592	1.3012
		1.3432	1.3852	1.4272	1.4691	1.5111	1.5531	1.5951	1.6371	1.6790	1.7210
		1.7588									
8	.8890	1.0807	1.1116	1.1459	1.1802	1.2144	1.2487	1.2830	1.3173	1.3516	1.3859
		1.4201	1.4544	1.4887	1.5230	1.5573	1.5916	1.6259	1.6601	1.6944	1.7287
		1.7596									
9	1.0160	1.2339	1.2578	1.2844	1.3110	1.3376	1.3641	1.3907	1.4173	1.4439	1.4705
		1.4971	1.5237	1.5503	1.5769	1.6035	1.6300	1.6566	1.6832	1.7098	1.7364
		1.7603									
10	1.1430	1.3870	1.4040	1.4229	1.4418	1.4607	1.4796	1.4985	1.5174	1.5363	1.5552
		1.5740	1.5929	1.6118	1.6307	1.6496	1.6685	1.6874	1.7063	1.7252	1.7441
		1.7611									
11	1.2573	1.5248	1.5356	1.5475	1.5595	1.5715	1.5835	1.5954	1.6074	1.6194	1.6313
		1.6433	1.6553	1.6672	1.6792	1.6912	1.7032	1.7151	1.7271	1.7391	1.7510
		1.7618									

(D) SECTIONAL FORCE OUTPUT CHORDS

VSGFC = .0127 .1270 .2540 .3810 .5080 .6350 .7620 .8890 1.0160 1.1430
1.2573

6. CONDITION DEFINITION

KVALUE = .0000
MACHNO = .5000

7. MODAL INPUT DEFINITION

```
NOMDS =     5        NUMBER OF DISPLACEMENT MODES
                     NUMBER OF MODAL INPUT POINTS/ZONE
NIPTS =     7    0      0
                     CONTROL ROTATION INPUT INDICATOR/CONTROL
  CRT =     0    0
DGUST =     F        DESCRETE GUST OPTION INDICATOR
GPGUST =    F        GRADUAL PENETRATION GUST OPTION IND.
GPGREF =      .0000  GRADUAL PENETRATION GUST REF. POINT

(8) MODAL INPUT POINTS AND DISPLACEMENTS FOR ZONE  1
 NO.      X          Y
 --- ---------- ----------

  1     .0000      .0000
  3    1.2165      .9230     1.0000      .8815      .0000      .0000      .0000
  5    1.6280      .9230     1.0000    -.3350      .0000      .0000      .0000
  6    1.6650     1.0720     1.0000    -.7465      .0000      .0000      .0000
  4    1.3971     1.0720     1.0000    -.7835      .0000      .0000      .0000
                                       -.5156      .0000      .0000      .0000

(8) MODAL INPUT POINTS AND DISPLACEMENTS FOR ZONE  2
 NO.      X          Y
 --- ---------- ----------

  3    1.2165      .9230     1.0000    -.3350      .0000      .0000      .0000
  4    1.3971     1.0720     1.0000    -.5156      .0000      .0000      .0000
  2    1.2120     1.0000     1.0000    -.3305      .0980      .0000      .0980

(8) MODAL INPUT POINTS AND DISPLACEMENTS FOR ZONE  3
 NO.      X          Y
 --- ---------- ----------

  5    1.6280      .9230     1.0000    -.7465      .0000      .0000      .0000
  6    1.6650     1.0720     1.0000    -.7835      .0000      .0000      .0000
  7    1.7630     1.0000     1.0000    -.8815      .0000    -.1159     -.1159

8. T E R M I N A T I O N   D E F I N I T I O N
   -------------------   -------------------

   LNAME = EXIT      RETURN, EXIT, OR OVERLAY NAME
      L1 =    -0     PRIMARY OVERLAY NUMBER
      L2 =    -0     SECONDARY OVERLAY NUMBER
```

CONTROL SURFACE 1 ROTATIONS

NASA TM X-2909 LEADING/TRAILING EDGE CONTROLS APR 12, 1975

THETA(ETA) = A0 + A1*F + A2*F**2 + A3*F**3, F = (ETA-YCSI)/(YCSO-YCSI)
YCSI,YCSO = CONTROL INBOARD, OUTBOARD SIDE EDGES

MODE	CUBIC COEFFICIENTS A0	A1	A2	A3	THETA F = 0	F = 1/3	F = 2/3	F = 1
1	.0	.0	.0	.0	.00000	.00000	.00000	.00000
2	.0	6.340703E-13	-1.019384E-11	9.559773E-12	.00000	-.00000	-.00000	.00000
3	1.016104E+00	7.324952E-03	1.541585E-03	-2.338434E-04	1.01610	1.01871	1.02160	1.02474
4	.0	.0	.0	.0	.00000	.00000	.00000	.00000
5	1.016104E+00	7.324952E-03	1.541585E-03	-2.338434E-04	1.01610	1.01871	1.02160	1.02474

CONTROL SURFACE 2 ROTATIONS

NASA TM X-2909 LEADING/TRAILING EDGE CONTROLS APR 12, 1975

THETA(ETA) = A0 + A1*F + A2*F**2 + A3*F**3, F = (ETA-YCSI)/(YCSO-YCSI)
YCSI,YCSO = CONTROL INBOARD, OUTBOARD SIDE EDGES

MODE	CUBIC COEFFICIENTS A0	A1	A2	A3	THETA F = 0	F = 1/3	F = 2/3	F = 1
1	.0	.0	.0	.0	.00000	.00000	.00000	.00000
2	-2.289097E-12	8.577102E-13	2.445092E-11	-2.701721E-11	-.00000	-.00000	.00000	-.00000
3	.0	.0	.0	.0	.00000	.00000	.00000	.00000
4	1.022736E+00	1.553415E-04	3.553837E-05	2.215302E-05	1.02274	1.02279	1.02286	1.02295
5	1.022736E+00	1.553415E-04	3.553837E-05	2.215302E-05	1.02274	1.02279	1.02286	1.02295

MAIN SURFACE PRESSURE TERM C-MATRIX - COND 1

NASA TM X-2909 LEADING/TRAILING EDGE CONTROLS APR 12, 1975

REDUCED FREQUENCY .0000 MACH NO. .5000

POINT	TERM 1 REAL	TERM 1 IMAG	TERM 2 REAL	TERM 2 IMAG	TERM 3 REAL	TERM 3 IMAG	TERM 4 REAL	TERM 4 IMAG
1	7.754387E+00	.0	-7.649929E+00	.0	7.064073E+00	.0	-5.842118E+00	.0
2	7.693480E+00	.0	-8.625895E+00	.0	9.724789E+00	.0	-1.039468E+01	.0
3	7.636129E+00	.0	-9.900990E+00	.0	1.287907E+01	.0	-1.525347E+01	.0
4	7.686280E+00	.0	-1.105694E+01	.0	1.533030E+01	.0	-1.862307E+01	.0
5	7.776570E+00	.0	-1.175983E+01	.0	1.663703E+01	.0	-2.029621E+01	.0
6	7.818928E+00	.0	-1.196509E+01	.0	1.697939E+01	.0	-2.071019E+01	.0
7	4.687290E+00	.0	-2.669386E+00	.0	-1.431068E+00	.0	6.990803E+00	.0
8	4.877560E+00	.0	-3.818516E+00	.0	7.456682E-01	.0	4.782557E+00	.0
9	5.085909E+00	.0	-5.162555E+00	.0	3.023015E+00	.0	3.002539E+00	.0
10	5.279466E+00	.0	-6.244908E+00	.0	4.603712E+00	.0	2.095998E+00	.0
11	5.421994E+00	.0	-6.861689E+00	.0	5.390626E+00	.0	1.737743E+00	.0
12	5.473421E+00	.0	-7.036278E+00	.0	5.590189E+00	.0	1.659843E+00	.0
13	3.221699E+00	.0	8.423571E-01	.0	-7.409865E+00	.0	1.315478E+01	.0
14	3.426157E+00	.0	-1.125045E-01	.0	-6.420462E+00	.0	1.406342E+01	.0
15	3.667265E+00	.0	-1.201225E+00	.0	-5.570642E+00	.0	1.564260E+01	.0
16	3.882507E+00	.0	-2.043147E+00	.0	-5.135595E+00	.0	1.714053E+01	.0
17	4.030714E+00	.0	-2.504481E+00	.0	-4.985731E+00	.0	1.801452E+01	.0
18	4.081850E+00	.0	-2.631360E+00	.0	-4.959263E+00	.0	1.825074E+01	.0
19	2.147982E+00	.0	3.697273E+00	.0	-1.038659E+01	.0	1.096900E+01	.0
20	2.340542E+00	.0	3.020256E+00	.0	-1.061012E+01	.0	1.382475E+01	.0
21	2.574055E+00	.0	2.272475E+00	.0	-1.112845E+01	.0	1.724376E+01	.0
22	2.782995E+00	.0	1.723362E+00	.0	-1.173351E+01	.0	1.989947E+01	.0
23	2.924309E+00	.0	1.441737E+00	.0	-1.214591E+01	.0	2.132100E+01	.0
24	2.972223E+00	.0	1.369326E+00	.0	-1.227186E+01	.0	2.169342E+01	.0
25	1.291982E+00	.0	5.723650E+00	.0	-9.975379E+00	.0	3.083377E+00	.0
26	1.468920E+00	.0	5.325853E+00	.0	-1.105500E+01	.0	6.013588E+00	.0
27	1.685648E+00	.0	4.914494E+00	.0	-1.248930E+01	.0	9.189363E+00	.0
28	1.880250E+00	.0	4.647660E+00	.0	-1.375195E+01	.0	1.145374E+01	.0
29	2.010744E+00	.0	4.536928E+00	.0	-1.450512E+01	.0	1.260461E+01	.0
30	2.054450E+00	.0	4.516253E+00	.0	-1.472192E+01	.0	1.289930E+01	.0
31	5.636002E-01	.0	6.930954E+00	.0	-6.944634E+00	.0	-5.468300E+00	.0
32	7.241389E-01	.0	6.783291E+00	.0	-8.428180E+00	.0	-3.814689E+00	.0
33	9.233100E-01	.0	6.671429E+00	.0	-1.024629E+01	.0	-2.272892E+00	.0
34	1.102404E+00	.0	6.653507E+00	.0	-1.173885E+01	.0	-1.364086E+00	.0
35	1.221428E+00	.0	6.692328E+00	.0	-1.258969E+01	.0	-9.735069E-01	.0
36	1.260728E+00	.0	6.716788E+00	.0	-1.282893E+01	.0	-8.845155E-01	.0
37	-6.467446E-02	.0	7.350252E+00	.0	-2.610762E+00	.0	-1.042386E+01	.0
38	9.002797E-02	.0	7.413238E+00	.0	-4.099372E+00	.0	-1.044932E+01	.0
39	2.735396E-01	.0	7.541312E+00	.0	-5.839311E+00	.0	-1.083451E+01	.0

C O N T R O L   S U R F A C E   N O . 1   P R E S S U R E   T E R M   C - M A T R I X - C O N D 1

N A S A   T M   X - 2 9 0 9   LEADING/TRAILING EDGE CONTROLS   APR 12, 1975

REDUCED FREQUENCY .0000   MACH NO. .5000

POINT	TERM 1 REAL	TERM 1 IMAG	TERM 2 REAL	TERM 2 IMAG	TERM 3 REAL	TERM 3 IMAG	TERM 4 REAL	TERM 4 IMAG
1	-2.937616E-03	.0	-1.923593E-04	.0	-1.763809E-04	.0	-1.648667E-04	.0
2	-3.162557E-02	.0	-2.751459E-04	.0	-2.500919E-04	.0	-2.326989E-04	.0
3	-4.179226E-02	.0	-4.670703E-04	.0	-4.210126E-04	.0	-3.898459E-04	.0
4	-4.364823E-02	.0	-7.535212E-04	.0	-6.873673E-04	.0	-6.393203E-04	.0
5	-4.253805E-02	.0	-9.440072E-04	.0	-8.876754E-04	.0	-8.366905E-04	.0
6	-4.264403E-02	.0	-9.913243E-04	.0	-9.446709E-04	.0	-8.956443E-04	.0
7	1.813854E-02	.0	-2.503236E-04	.0	-2.274425E-04	.0	-2.116233E-04	.0
8	-9.124658E-03	.0	-3.576280E-04	.0	-3.215361E-04	.0	-2.975347E-04	.0
9	-1.684118E-02	.0	-6.080339E-04	.0	-5.406082E-04	.0	-4.970915E-04	.0
10	-1.699149E-02	.0	-9.626335E-04	.0	-8.698357E-04	.0	-8.047508E-04	.0
11	-1.572845E-02	.0	-1.158173E-03	.0	-1.087116E-03	.0	-1.022845E-03	.0
12	-1.533356E-02	.0	-1.197927E-03	.0	-1.141760E-03	.0	-1.081526E-03	.0
13	2.414142E-02	.0	-3.406570E-04	.0	-3.048794E-04	.0	-2.815529E-04	.0
14	-3.457209E-03	.0	-4.997612E-04	.0	-4.402694E-04	.0	-4.032789E-04	.0
15	-1.001174E-02	.0	-8.916243E-04	.0	-7.719958E-04	.0	-7.002398E-04	.0
16	-9.817121E-03	.0	-1.401270E-03	.0	-1.247709E-03	.0	-1.144506E-03	.0
17	-8.566251E-03	.0	-1.598582E-03	.0	-1.498960E-03	.0	-1.407269E-03	.0
18	-7.897209E-03	.0	-1.621741E-03	.0	-1.548901E-03	.0	-1.465998E-03	.0
19	1.895127E-02	.0	-5.117291E-04	.0	-4.458779E-04	.0	-4.062912E-04	.0
20	-1.214219E-02	.0	-7.998063E-04	.0	-6.790952E-04	.0	-6.105592E-04	.0
21	-2.003844E-02	.0	-1.554205E-03	.0	-1.289139E-03	.0	-1.143014E-03	.0
22	-2.172479E-02	.0	-2.336781E-03	.0	-2.051404E-03	.0	-1.863847E-03	.0
23	-2.096966E-02	.0	-2.462332E-03	.0	-2.317994E-03	.0	-2.174068E-03	.0
24	-2.049999E-02	.0	-2.440468E-03	.0	-2.347666E-03	.0	-2.222761E-03	.0
25	4.320620E-03	.0	-8.770387E-04	.0	-7.312409E-04	.0	-6.513071E-04	.0
26	-3.748643E-02	.0	-1.532280E-03	.0	-1.221529E-03	.0	-1.063245E-03	.0
27	-5.511850E-02	.0	-3.277111E-03	.0	-2.562809E-03	.0	-2.198117E-03	.0
28	-6.359236E-02	.0	-4.295014E-03	.0	-3.756005E-03	.0	-3.391254E-03	.0
29	-6.600246E-02	.0	-4.091906E-03	.0	-3.907417E-03	.0	-3.671314E-03	.0
30	-6.654706E-02	.0	-3.960234E-03	.0	-3.875022E-03	.0	-3.678160E-03	.0
31	-3.347494E-03	.0	-1.871081E-03	.0	-1.437096E-03	.0	-1.227852E-03	.0
32	-7.116237E-02	.0	-4.016657E-03	.0	-2.829514E-03	.0	-2.309622E-03	.0
33	-1.110921E-01	.0	-8.623017E-03	.0	-6.347444E-03	.0	-5.228008E-03	.0
34	-1.318891E-01	.0	-8.534003E-03	.0	-7.611566E-03	.0	-6.882343E-03	.0
35	-1.402966E-01	.0	-7.288290E-03	.0	-7.226493E-03	.0	-6.832270E-03	.0
36	-1.426672E-01	.0	-6.888652E-03	.0	-7.026260E-03	.0	-6.712761E-03	.0
37	3.278854E-02	.0	-6.124615E-03	.0	-3.856165E-03	.0	-2.987012E-03	.0
38	-7.881541E-02	.0	-2.072972E-02	.0	-1.087906E-02	.0	-7.529070E-03	.0
39	-1.431710E-01	.0	-2.592582E-02	.0	-1.891498E-02	.0	-1.522498E-02	.0

40	-1.726583E-01	.0	-1.722536E-02	.0	-1.685036E-02	.0	-1.545227E-02	.0
41	-1.856851E-01	.0	-1.263848E-02	.0	-1.469774E-02	.0	-1.419174E-02	.0
42	-1.892720E-01	.0	-1.145003E-02	.0	-1.403388E-02	.0	-1.372322E-02	.0
43	1.184195E+00	.0	2.227928E-01	.0	7.241038E-03	.0	-1.846530E-02	.0
44	1.450374E-02	.0	-1.904640E-01	.0	-1.337537E-01	.0	-8.130192E-02	.0
45	-5.924562E-02	.0	-1.611794E-01	.0	-9.297274E-02	.0	-6.477933E-02	.0
46	-8.552549E-02	.0	-1.556080E-01	.0	-7.215890E-02	.0	-5.024232E-02	.0
47	-9.656090E-02	.0	-1.537709E-01	.0	-6.247532E-02	.0	-4.244140E-02	.0
48	-9.970557E-02	.0	-1.532415E-01	.0	-5.997010E-02	.0	-4.032879E-02	.0
49	1.467607E+00	.0	1.230505E+00	.0	9.777924E-01	.0	7.378049E-01	.0
50	3.187935E-01	.0	1.300600E-01	.0	-1.182791E-02	.0	-1.319418E-01	.0
51	2.564263E-01	.0	7.316946E-02	.0	-2.708723E-02	.0	-1.068470E-01	.0
52	2.402520E-01	.0	4.261779E-02	.0	-4.779855E-02	.0	-1.151405E-01	.0
53	2.341458E-01	.0	3.187354E-02	.0	-5.206877E-02	.0	-1.122933E-01	.0
54	2.320022E-01	.0	2.894034E-02	.0	-5.308392E-02	.0	-1.113456E-01	.0
55	3.986675E-01	.0	3.926666E-01	.0	4.073866E-01	.0	4.179993E-01	.0
56	3.038338E-01	.0	2.875235E-01	.0	2.981707E-01	.0	3.060810E-01	.0
57	2.661586E-01	.0	2.399826E-01	.0	2.474138E-01	.0	2.533071E-01	.0
58	2.494470E-01	.0	2.163813E-01	.0	2.218755E-01	.0	2.265804E-01	.0
59	2.383072E-01	.0	2.014285E-01	.0	2.059333E-01	.0	2.100282E-01	.0
60	2.338205E-01	.0	1.958194E-01	.0	2.000678E-01	.0	2.040074E-01	.0
61	1.153294E-01	.0	9.716837E-02	.0	9.992430E-02	.0	1.019167E-01	.0
62	6.294423E-02	.0	4.258538E-02	.0	4.487181E-02	.0	4.659957E-02	.0
63	2.763169E-02	.0	4.675159E-03	.0	6.442909E-03	.0	7.880802E-03	.0
64	-5.426974E-03	.0	-3.055854E-02	.0	-2.918634E-02	.0	-2.796803E-02	.0
65	-3.073540E-02	.0	-5.725128E-02	.0	-5.610665E-02	.0	-5.501355E-02	.0
66	-3.963196E-02	.0	-6.661280E-02	.0	-6.553797E-02	.0	-6.448286E-02	.0
67	-2.859391E-02	.0	-4.596276E-02	.0	-4.469431E-02	.0	-4.373605E-02	.0
68	-5.208175E-02	.0	-7.044571E-02	.0	-6.933777E-02	.0	-6.846506E-02	.0
69	-9.832884E-02	.0	-1.179324E-01	.0	-1.170162E-01	.0	-1.162455E-01	.0
70	-1.495204E-01	.0	-1.702406E-01	.0	-1.694849E-01	.0	-1.687995E-01	.0
71	-1.858378E-01	.0	-2.073249E-01	.0	-2.066711E-01	.0	-2.060392E-01	.0
72	-1.967932E-01	.0	-2.185545E-01	.0	-2.179349E-01	.0	-2.173210E-01	.0

C O N T R O L   S U R F A C E   N O . 2   P R E S S U R E   T E R M   C - M A T R I X - C O N D 1

N A S A   T M   X - 2 9 0 9   LEADING/TRAILING EDGE CONTROLS   APR 12, 1975

REDUCED FREQUENCY .0000   MACH NO. .5000

POINT	TERM 1 REAL	TERM 1 IMAG	TERM 2 REAL	TERM 2 IMAG	TERM 3 REAL	TERM 3 IMAG	TERM 4 REAL	TERM 4 IMAG
1	-1.449957E-02	.0	-8.345531E-04	.0	-6.749793E-04	.0	-5.968619E-04	.0
2	-2.158417E-03	.0	-1.128825E-03	.0	-9.100740E-04	.0	-8.033076E-04	.0
3	1.429282E-02	.0	-1.820414E-03	.0	-1.457977E-03	.0	-1.282144E-03	.0
4	3.254410E-02	.0	-3.146432E-03	.0	-2.495672E-03	.0	-2.182541E-03	.0
5	5.748565E-02	.0	-4.774025E-03	.0	-3.758198E-03	.0	-3.272131E-03	.0
6	7.183114E-02	.0	-5.494041E-03	.0	-4.316854E-03	.0	-3.754271E-03	.0
7	-2.316715E-02	.0	-1.024290E-03	.0	-8.269561E-04	.0	-7.305253E-04	.0
8	-1.317930E-02	.0	-1.373466E-03	.0	-1.104917E-03	.0	-9.741294E-04	.0
9	1.258479E-03	.0	-2.189756E-03	.0	-1.748365E-03	.0	-1.534905E-03	.0
10	1.888203E-02	.0	-3.766466E-03	.0	-2.972636E-03	.0	-2.592556E-03	.0
11	4.486426E-02	.0	-5.717508E-03	.0	-4.470837E-03	.0	-3.878096E-03	.0
12	5.997819E-02	.0	-6.572553E-03	.0	-5.127285E-03	.0	-4.441160E-03	.0
13	-3.004940E-02	.0	-1.270343E-03	.0	-1.023581E-03	.0	-9.032491E-04	.0
14	-2.025976E-02	.0	-1.704537E-03	.0	-1.367597E-03	.0	-1.203979E-03	.0
15	-5.786093E-03	.0	-2.754145E-03	.0	-2.188404E-03	.0	-1.916259E-03	.0
16	1.245930E-02	.0	-4.903295E-03	.0	-3.835912E-03	.0	-3.329457E-03	.0
17	4.034599E-02	.0	-7.653601E-03	.0	-5.913296E-03	.0	-5.095160E-03	.0
18	5.658882E-02	.0	-8.847297E-03	.0	-6.814314E-03	.0	-5.860366E-03	.0
19	-3.701452E-02	.0	-1.628426E-03	.0	-1.308657E-03	.0	-1.153198E-03	.0
20	-2.676910E-02	.0	-2.216486E-03	.0	-1.771042E-03	.0	-1.555783E-03	.0
21	-1.151210E-02	.0	-3.738942E-03	.0	-2.945544E-03	.0	-2.567667E-03	.0
22	8.061464E-03	.0	-7.132712E-03	.0	-5.495127E-03	.0	-4.730139E-03	.0
23	3.910637E-02	.0	-1.165123E-02	.0	-8.825489E-03	.0	-7.521314E-03	.0
24	5.710283E-02	.0	-1.357847E-02	.0	-1.024435E-02	.0	-8.708863E-03	.0
25	-4.445083E-02	.0	-2.167230E-03	.0	-1.734754E-03	.0	-1.525545E-03	.0
26	-3.342703E-02	.0	-3.044803E-03	.0	-2.415645E-03	.0	-2.114367E-03	.0
27	-1.699642E-02	.0	-5.552576E-03	.0	-4.304740E-03	.0	-3.721994E-03	.0
28	4.430618E-03	.0	-1.170272E-02	.0	-8.789407E-03	.0	-7.463374E-03	.0
29	4.020185E-02	.0	-2.021294E-02	.0	-1.483020E-02	.0	-1.241825E-02	.0
30	6.048676E-02	.0	-2.375200E-02	.0	-1.733992E-02	.0	-1.447350E-02	.0
31	-5.307069E-02	.0	-3.055333E-03	.0	-2.427903E-03	.0	-2.127414E-03	.0
32	-4.108634E-02	.0	-4.553187E-03	.0	-3.556069E-03	.0	-3.089329E-03	.0
33	-2.327396E-02	.0	-9.508859E-03	.0	-7.105863E-03	.0	-6.035360E-03	.0
34	4.377600E-04	.0	-2.281503E-02	.0	-1.633380E-02	.0	-1.352517E-02	.0
35	4.314578E-02	.0	-4.235142E-02	.0	-2.928560E-02	.0	-2.374746E-02	.0
36	6.547714E-02	.0	-5.012128E-02	.0	-3.445322E-02	.0	-2.782572E-02	.0
37	-6.331131E-02	.0	-4.653048E-03	.0	-3.629767E-03	.0	-3.154302E-03	.0
38	-5.034049E-02	.0	-8.046752E-03	.0	-5.887624E-03	.0	-4.984915E-03	.0
39	-3.122075E-02	.0	-2.183553E-02	.0	-1.447404E-02	.0	-1.165082E-02	.0

40	-5.272126E-03	.0	-6.016679E-02	.0	-3.814721E-02	.0	-2.976889E-02	.0
41	4.621549E-02	.0	-1.255641E-01	.0	-7.478589E-02	.0	-5.617772E-02	.0
42	6.613495E-02	.0	-1.487173E-01	.0	-8.822389E-02	.0	-6.600471E-02	.0
43	-7.660795E-02	.0	-4.674580E-03	.0	-5.552653E-03	.0	-5.302573E-03	.0
44	-6.273519E-02	.0	2.544020E-03	.0	-1.262728E-02	.0	-1.225403E-02	.0
45	-4.262328E-02	.0	-5.862809E-03	.0	-4.809173E-02	.0	-4.181395E-02	.0
46	-1.517077E-02	.0	-5.825816E-02	.0	-1.474317E-01	.0	-1.211157E-01	.0
47	1.041630E+00	.0	-2.833811E-02	.0	-3.363922E-01	.0	-2.738970E-01	.0
48	1.051383E+00	.0	-7.405302E-02	.0	-3.943950E-01	.0	-3.170203E-01	.0
49	-9.498181E-02	.0	-2.112572E-02	.0	-1.171817E-02	.0	-8.070563E-03	.0
50	-8.039928E-02	.0	1.503547E-02	.0	1.579581E-02	.0	7.671922E-03	.0
51	-5.956664E-02	.0	7.196519E-02	.0	4.552747E-02	.0	4.354799E-03	.0
52	-3.022142E-02	.0	1.791614E-01	.0	9.781365E-02	.0	-1.623101E-02	.0
53	1.033510E+00	.0	1.114773E+00	.0	7.565469E-01	.0	3.701080E-01	.0
54	1.046636E+00	.0	1.145716E+00	.0	7.649295E-01	.0	3.507220E-01	.0
55	-1.238257E-01	.0	-6.614405E-02	.0	-5.835464E-02	.0	-5.405781E-02	.0
56	-1.092842E-01	.0	-3.440643E-02	.0	-2.196212E-02	.0	-1.485075E-02	.0
57	-8.268588E-02	.0	2.328809E-02	.0	4.638560E-02	.0	6.003358E-02	.0
58	-4.188313E-02	.0	1.151949E-01	.0	1.587981E-01	.0	1.854946E-01	.0
59	2.938767E-02	.0	2.315637E-01	.0	2.950186E-01	.0	3.347711E-01	.0
60	6.139768E-02	.0	2.762889E-01	.0	3.448263E-01	.0	3.878207E-01	.0
61	-1.513999E-01	.0	-1.013363E-01	.0	-9.475541E-02	.0	-9.121858E-02	.0
62	-1.410889E-01	.0	-8.337997E-02	.0	-7.481331E-02	.0	-7.014106E-02	.0
63	-1.168988E-01	.0	-4.671561E-02	.0	-3.453944E-02	.0	-2.776429E-02	.0
64	-7.612492E-02	.0	8.334699E-03	.0	2.502485E-02	.0	3.448522E-02	.0
65	-1.641967E-02	.0	7.866164E-02	.0	9.871621E-02	.0	1.101818E-01	.0
66	1.345480E-02	.0	1.121575E-01	.0	1.333009E-01	.0	1.454069E-01	.0
67	-1.565922E-01	.0	-1.110233E-01	.0	-1.049842E-01	.0	-1.017479E-01	.0
68	-1.616184E-01	.0	-1.117041E-01	.0	-1.045646E-01	.0	-1.007039E-01	.0
69	-1.477762E-01	.0	-9.148440E-02	.0	-8.263993E-02	.0	-7.780129E-02	.0
70	-1.151788E-01	.0	-5.227242E-02	.0	-4.160633E-02	.0	-3.571586E-02	.0
71	-7.084920E-02	.0	-3.010343E-03	.0	8.992582E-03	.0	1.565237E-02	.0
72	-5.035099E-02	.0	1.927960E-02	.0	3.175232E-02	.0	3.868046E-02	.0

D O W N W A S H   M A T R I X - C O N D 1

N A S A   T M   X - 2 9 0 9   LEADING/TRAILING EDGE CONTROLS   APR 12, 1975

REDUCED FREQUENCY   .0000   MACH NO.   .5000

POINT	MODE 1 REAL	MODE 1 IMAG	MODE 2 REAL	MODE 2 IMAG	MODE 3 REAL	MODE 3 IMAG	MODE 4 REAL	MODE 4 IMAG
1	1.940402E-15	.0	9.903178E-01	.0	.0	-.0	.0	-.0
2	2.610322E-15	.0	1.023497E+00	.0	.0	-.0	.0	-.0
3	1.943753E-15	.0	1.037342E+00	.0	.0	-.0	.0	-.0
4	1.588210E-15	.0	1.032726E+00	.0	.0	-.0	.0	-.0
5	1.414072E-15	.0	1.009365E+00	.0	.0	-.0	.0	-.0
6	1.342061E-15	.0	9.859773E-01	.0	.0	-.0	.0	-.0
7	1.365051E-15	.0	9.903178E-01	.0	.0	-.0	.0	-.0
8	2.653884E-15	.0	1.023497E+00	.0	.0	-.0	.0	-.0
9	2.024017E-15	.0	1.037342E+00	.0	.0	-.0	.0	-.0
10	1.618147E-15	.0	1.032726E+00	.0	.0	-.0	.0	-.0
11	1.434998E-15	.0	1.009365E+00	.0	.0	-.0	.0	-.0
12	1.361203E-15	.0	9.859773E-01	.0	.0	-.0	.0	-.0
13	8.903013E-16	.0	9.903178E-01	.0	.0	-.0	.0	-.0
14	2.512650E-15	.0	1.023497E+00	.0	.0	-.0	.0	-.0
15	2.146319E-15	.0	1.037342E+00	.0	.0	-.0	.0	-.0
16	1.654186E-15	.0	1.032726E+00	.0	.0	-.0	.0	-.0
17	1.457471E-15	.0	1.009365E+00	.0	.0	-.0	.0	-.0
18	1.381266E-15	.0	9.859773E-01	.0	.0	-.0	.0	-.0
19	5.372528E-16	.0	9.903178E-01	.0	.0	-.0	.0	-.0
20	2.016966E-15	.0	1.023497E+00	.0	.0	-.0	.0	-.0
21	2.387182E-15	.0	1.037342E+00	.0	.0	-.0	.0	-.0
22	1.708647E-15	.0	1.032726E+00	.0	.0	-.0	.0	-.0
23	1.485653E-15	.0	1.009365E+00	.0	.0	-.0	.0	-.0
24	1.405243E-15	.0	9.859773E-01	.0	.0	-.0	.0	-.0
25	3.763822E-16	.0	9.903178E-01	.0	.0	-.0	.0	-.0
26	1.202686E-15	.0	1.023497E+00	.0	.0	-.0	.0	-.0
27	2.841497E-15	.0	1.037342E+00	.0	.0	-.0	.0	-.0
28	1.811236E-15	.0	1.032726E+00	.0	.0	-.0	.0	-.0
29	1.527409E-15	.0	1.009365E+00	.0	.0	-.0	.0	-.0
30	1.438134E-15	.0	9.859773E-01	.0	.0	-.0	.0	-.0
31	4.813425E-16	.0	9.903178E-01	.0	.0	-.0	.0	-.0
32	3.836487E-16	.0	1.023497E+00	.0	.0	-.0	.0	-.0
33	2.908994E-15	.0	1.037342E+00	.0	.0	-.0	.0	-.0
34	2.069283E-15	.0	1.032726E+00	.0	.0	-.0	.0	-.0
35	1.609046E-15	.0	1.009365E+00	.0	.0	-.0	.0	-.0
36	1.497328E-15	.0	9.859773E-01	.0	.0	-.0	.0	-.0
37	7.823789E-16	.0	9.903178E-01	.0	.0	-.0	.0	-.0
38	-8.203887E-17	.0	1.023497E+00	.0	.0	-.0	.0	-.0
39	1.882953E-15	.0	1.037342E+00	.0	.0	-.0	.0	-.0

40	3.020652E-15	.0	1.032726E+00	.0	.0	-.0	.0	-.0
41	1.802257E-15	.0	1.009365E+00	.0	.0	-.0	.0	-.0
42	1.627768E-15	.0	9.859773E-01	.0	.0	-.0	.0	-.0
43	5.174873E-15	.0	9.903178E-01	.0	9.920366E-01	.0	.0	-.0
44	-6.971441E-17	.0	1.023497E+00	.0	.0	-.0	.0	-.0
45	4.512733E-16	.0	1.037342E+00	.0	.0	-.0	.0	-.0
46	3.207784E-15	.0	1.032726E+00	.0	.0	-.0	.0	-.0
47	-6.103700E-15	.0	1.009365E+00	.0	.0	-.0	1.009365E+00	.0
48	-4.110185E-14	.0	9.859773E-01	.0	.0	-.0	9.859776E-01	.0
49	-3.823138E-15	.0	9.903178E-01	.0	9.920366E-01	.0	.0	-.0
50	4.481205E-16	.0	1.023497E+00	.0	.0	-.0	.0	-.0
51	-1.581878E-16	.0	1.037342E+00	.0	.0	-.0	.0	-.0
52	1.376393E-15	.0	1.032726E+00	.0	.0	-.0	.0	-.0
53	-4.748613E-15	.0	1.009365E+00	.0	.0	-.0	1.009365E+00	.0
54	-3.670757E-14	.0	9.859773E-01	.0	.0	-.0	9.859776E-01	.0
55	1.060963E-15	.0	9.903178E-01	.0	.0	-.0	.0	-.0
56	7.839617E-16	.0	1.023497E+00	.0	.0	-.0	.0	-.0
57	5.099306E-17	.0	1.037342E+00	.0	.0	-.0	.0	-.0
58	1.665043E-17	.0	1.032726E+00	.0	.0	-.0	.0	-.0
59	9.405522E-16	.0	1.009365E+00	.0	.0	-.0	.0	-.0
60	1.769595E-15	.0	9.859773E-01	.0	.0	-.0	.0	-.0
61	1.088052E-15	.0	9.903178E-01	.0	.0	-.0	.0	-.0
62	9.419866E-16	.0	1.023497E+00	.0	.0	-.0	.0	-.0
63	5.289617E-16	.0	1.037342E+00	.0	.0	-.0	.0	-.0
64	7.436687E-17	.0	1.032726E+00	.0	.0	-.0	.0	-.0
65	4.585763E-17	.0	1.009365E+00	.0	.0	-.0	.0	-.0
66	1.534743E-16	.0	9.859773E-01	.0	.0	-.0	.0	-.0
67	1.105157E-15	.0	9.903178E-01	.0	.0	-.0	.0	-.0
68	1.019049E-15	.0	1.023497E+00	.0	.0	-.0	.0	-.0
69	7.769364E-16	.0	1.037342E+00	.0	.0	-.0	.0	-.0
70	4.192094E-16	.0	1.032726E+00	.0	.0	-.0	.0	-.0
71	1.703875E-16	.0	1.009365E+00	.0	.0	-.0	.0	-.0
72	1.146981E-16	.0	9.859773E-01	.0	.0	-.0	.0	-.0

R E S I D U A L   D O W N W A S H   M A T R I X - C O N D 1

N A S A   T M   X - 2 9 0 9   LEADING/TRAILING EDGE CONTROLS   APR 12, 1975

REDUCED FREQUENCY   .0000   MACH NO. .5000

POINT	MODE 1 REAL	MODE 1 IMAG	MODE 2 REAL	MODE 2 IMAG	MODE 3 REAL	MODE 3 IMAG	MODE 4 REAL	MODE 4 IMAG
1	1.940402E-15	.0	9.903178E-01	.0	2.986567E-03	.0	1.482939E-02	.0
2	2.610322E-15	.0	1.023497E+00	.0	3.213723E-02	.0	2.207716E-03	.0
3	1.943753E-15	.0	1.037342E+00	.0	4.246928E-02	.0	-1.461742E-02	.0
4	1.598210E-15	.0	1.032726E+00	.0	4.435759E-02	.0	-3.328339E-02	.0
5	1.414072E-15	.0	1.009365E+00	.0	4.323119E-02	.0	-5.879168E-02	.0
6	1.342061E-15	.0	9.859773E-01	.0	4.333930E-02	.0	-7.346319E-02	.0
7	1.365051E-15	.0	9.903178E-01	.0	-1.842851E-02	.0	2.369407E-02	.0
8	2.653884E-15	.0	1.023497E+00	.0	9.274652E-03	.0	1.347921E-02	.0
9	2.024017E-15	.0	1.037342E+00	.0	1.711757E-02	.0	-1.286655E-03	.0
10	1.618147E-15	.0	1.032726E+00	.0	1.727333E-02	.0	-1.931058E-02	.0
11	1.434998E-15	.0	1.009365E+00	.0	1.599166E-02	.0	-4.588314E-02	.0
12	1.361203E-15	.0	9.859773E-01	.0	1.559078E-02	.0	-6.134054E-02	.0
13	8.903013E-16	.0	9.903178E-01	.0	-2.452730E-02	.0	3.073285E-02	.0
14	2.512650E-15	.0	1.023497E+00	.0	3.517130E-03	.0	2.072072E-02	.0
15	2.146319E-15	.0	1.037342E+00	.0	1.018053E-02	.0	5.918192E-03	.0
16	1.654186E-15	.0	1.032726E+00	.0	9.987141E-03	.0	-1.274160E-02	.0
17	1.457471E-15	.0	1.009365E+00	.0	8.717897E-03	.0	-4.126178E-02	.0
18	1.381266E-15	.0	9.859773E-01	.0	8.038314E-03	.0	-5.787366E-02	.0
19	5.372528E-16	.0	9.903178E-01	.0	-1.925213E-02	.0	3.785639E-02	.0
20	2.016966E-15	.0	1.023497E+00	.0	1.234450E-02	.0	2.737816E-02	.0
21	2.387182E-15	.0	1.037342E+00	.0	2.037425E-02	.0	1.177457E-02	.0
22	1.708647E-15	.0	1.032726E+00	.0	2.209450E-02	.0	-8.243339E-03	.0
23	1.485653E-15	.0	1.009365E+00	.0	2.132846E-02	.0	-3.999320E-02	.0
24	1.405243E-15	.0	9.859773E-01	.0	2.085111E-02	.0	-5.839844E-02	.0
25	3.763822E-16	.0	9.903178E-01	.0	-4.382796E-03	.0	4.546189E-02	.0
26	1.202686E-15	.0	1.023497E+00	.0	3.810298E-02	.0	3.418762E-02	.0
27	2.841497E-15	.0	1.037342E+00	.0	5.603360E-02	.0	1.738394E-02	.0
28	1.811236E-15	.0	1.032726E+00	.0	6.465294E-02	.0	-4.529056E-03	.0
29	1.527409E-15	.0	1.009365E+00	.0	6.710054E-02	.0	-4.111193E-02	.0
30	1.438134E-15	.0	9.859773E-01	.0	6.765288E-02	.0	-6.185735E-02	.0
31	4.813425E-16	.0	9.903178E-01	.0	3.417037E-03	.0	5.427790E-02	.0
32	3.836487E-16	.0	1.023497E+00	.0	7.234164E-02	.0	4.202137E-02	.0
33	2.908994E-15	.0	1.037342E+00	.0	1.129529E-01	.0	2.380498E-02	.0
34	2.069283E-15	.0	1.032726E+00	.0	1.340858E-01	.0	-4.432886E-04	.0
35	1.609046E-15	.0	1.009365E+00	.0	1.426189E-01	.0	-4.411859E-02	.0
36	1.497328E-15	.0	9.859773E-01	.0	1.450245E-01	.0	-6.695618E-02	.0
37	7.823789E-16	.0	9.903178E-01	.0	-3.326647E-02	.0	6.475166E-02	.0
38	-8.203887E-17	.0	1.023497E+00	.0	8.025155E-02	.0	5.148659E-02	.0
39	1.882953E-15	.0	1.037342E+00	.0	1.456922E-01	.0	3.193474E-02	.0

40	3.020652E-15	.0	1.032726E+00	.0	1.755874E-01	.0	5.403353E-03	.0
41	1.802257E-15	.0	1.009365E+00	.0	1.887874E-01	.0	-4.724283E-02	.0
42	1.627768E-15	.0	9.859773E-01	.0	1.924224E-01	.0	-6.761088E-02	.0
43	5.174873E-15	.0	9.903178E-01	.0	-2.128769E-01	.0	7.835073E-02	.0
44	-6.971441E-17	.0	1.023497E+00	.0	-1.315499E-02	.0	6.416184E-02	.0
45	4.512733E-16	.0	1.037342E+00	.0	6.150855E-02	.0	4.359590E-02	.0
46	3.207784E-15	.0	1.032726E+00	.0	8.814214E-02	.0	1.553266E-02	.0
47	-6.103700E-15	.0	1.009365E+00	.0	9.932871E-02	.0	-5.592502E-02	.0
48	-4.110185E-14	.0	9.859773E-01	.0	1.025168E-01	.0	-8.927711E-02	.0
49	-3.823138E-15	.0	9.903178E-01	.0	-5.095535E-01	.0	9.714517E-02	.0
50	4.481205E-16	.0	1.023497E+00	.0	-3.248928E-01	.0	8.222415E-02	.0
51	-1.581878E-16	.0	1.037342E+00	.0	-2.610750E-01	.0	6.090804E-02	.0
52	1.376393E-15	.0	1.032726E+00	.0	-2.443865E-01	.0	3.087758E-02	.0
53	-4.748613E-15	.0	1.009365E+00	.0	-2.380961E-01	.0	-4.785042E-02	.0
54	-3.670757E-14	.0	9.859773E-01	.0	-2.358947E-01	.0	-8.466773E-02	.0
55	1.060963E-15	.0	9.903178E-01	.0	-4.084943E-01	.0	1.266545E-01	.0
56	7.839617E-16	.0	1.023497E+00	.0	-3.112211E-01	.0	1.107526E-01	.0
57	5.099306E-17	.0	1.037342E+00	.0	-2.725250E-01	.0	8.455921E-02	.0
58	1.665043E-17	.0	1.032726E+00	.0	-2.553382E-01	.0	4.280773E-02	.0
59	9.405522E-16	.0	1.009365E+00	.0	-2.438888E-01	.0	-3.010969E-02	.0
60	1.769595E-15	.0	9.859773E-01	.0	-2.392812E-01	.0	-6.285737E-02	.0
61	1.088052E-15	.0	9.903178E-01	.0	-1.180287E-01	.0	1.548632E-01	.0
62	9.419866E-16	.0	1.023497E+00	.0	-6.432813E-02	.0	1.443138E-01	.0
63	5.289617E-16	.0	1.037342E+00	.0	-2.811901E-02	.0	1.195657E-01	.0
64	7.436687E-17	.0	1.032726E+00	.0	5.776666E-03	.0	7.785273E-02	.0
65	4.585763E-17	.0	1.009365E+00	.0	3.172337E-02	.0	1.677481E-02	.0
66	1.534743E-16	.0	9.859773E-01	.0	4.084410E-02	.0	-1.378608E-02	.0
67	1.105157E-15	.0	9.903178E-01	.0	2.944974E-02	.0	1.601757E-01	.0
68	1.019049E-15	.0	1.023497E+00	.0	5.352739E-02	.0	1.653162E-01	.0
69	7.769364E-16	.0	1.037342E+00	.0	1.009294E-01	.0	1.511548E-01	.0
70	4.192094E-16	.0	1.032726E+00	.0	1.533971E-01	.0	1.178078E-01	.0
71	1.703875E-16	.0	1.009365E+00	.0	1.906197E-01	.0	7.245981E-02	.0
72	1.146981E-16	.0	9.859773E-01	.0	2.018484E-01	.0	5.149078E-02	.0

COEFFICIENTS OF MAIN SURFACE PRESSURE TERMS - COND 1

NASA TM X-2909 LEADING/TRAILING EDGE CONTROLS APR 12, 1975

REDUCED FREQUENCY .0000 MACH NO. .5000

TERM	MODE 1 REAL	MODE 1 IMAG	MODE 2 REAL	MODE 2 IMAG	MODE 3 REAL	MODE 3 IMAG	MODE 4 REAL	MODE 4 IMAG
1	3.883609E-16	-.0	3.361654E-01	-.0	-7.273039E-03	-.0	4.729554E-03	-.0
2	1.221745E-16	-.0	2.445628E-01	-.0	-1.877759E-02	-.0	7.720774E-03	-.0
3	-1.280334E-16	-.0	1.001717E-01	-.0	-1.293749E-02	-.0	5.933631E-03	-.0
4	-3.936767E-17	-.0	7.886658E-02	-.0	2.482660E-03	-.0	3.940784E-03	-.0
5	1.648072E-16	-.0	4.307525E-02	-.0	8.983097E-03	-.0	2.266429E-03	-.0
6	2.810587E-16	-.0	3.621822E-02	-.0	2.778815E-03	-.0	1.433237E-03	-.0
7	2.347815E-16	-.0	2.131978E-02	-.0	-3.212095E-03	-.0	1.001162E-03	-.0
8	3.370255E-16	-.0	1.643457E-02	-.0	-2.924578E-03	-.0	7.373079E-04	-.0
9	6.311609E-16	-.0	8.423349E-03	-.0	-2.692234E-04	-.0	4.933207E-04	-.0
10	8.816969E-16	-.0	5.047005E-03	-.0	1.099113E-03	-.0	3.067456E-04	-.0
11	6.948404E-16	-.0	1.546250E-03	-.0	7.086630E-04	-.0	1.537787E-04	-.0
12	3.052058E-16	-.0	5.187021E-04	-.0	2.302483E-04	-.0	4.816738E-05	-.0
13	-1.611884E-15	-.0	-8.110264E-04	-.0	2.897239E-02	-.0	-3.328960E-02	-.0
14	-2.418345E-15	-.0	-1.423699E-01	-.0	3.155142E-02	-.0	-2.275696E-02	-.0
15	1.864313E-16	-.0	-1.011692E-01	-.0	1.459662E-02	-.0	-1.107736E-02	-.0
16	1.214253E-15	-.0	-1.125810E-01	-.0	-5.137993E-04	-.0	-5.870671E-03	-.0
17	8.473562E-17	-.0	-7.540008E-02	-.0	-4.830006E-03	-.0	-3.210002E-03	-.0
18	-1.386431E-15	-.0	-6.596782E-02	-.0	-5.190904E-04	-.0	-2.545812E-03	-.0
19	-1.233032E-15	-.0	-4.207292E-02	-.0	4.445863E-03	-.0	-2.098506E-03	-.0
20	-9.741994E-16	-.0	-3.163389E-02	-.0	4.665474E-03	-.0	-1.750699E-03	-.0
21	-1.557272E-15	-.0	-1.700112E-02	-.0	2.603365E-03	-.0	-1.352135E-03	-.0
22	-2.654035E-15	-.0	-9.727761E-03	-.0	1.052034E-03	-.0	-1.231873E-03	-.0
23	-2.321390E-15	-.0	-3.132194E-03	-.0	7.389492E-04	-.0	-8.692040E-04	-.0
24	-1.141960E-15	-.0	-9.281447E-04	-.0	3.416865E-04	-.0	-4.103579E-04	-.0
25	1.611937E-15	-.0	3.567457E-02	-.0	1.347160E-02	-.0	1.316797E-02	-.0
26	1.998208E-15	-.0	-1.470646E-02	-.0	1.208620E-02	-.0	8.026779E-03	-.0
27	-5.652118E-16	-.0	-2.580239E-02	-.0	2.227122E-03	-.0	3.122031E-04	-.0
28	-1.783633E-15	-.0	-4.846438E-02	-.0	-3.010670E-03	-.0	-2.850140E-03	-.0
29	-8.416337E-16	-.0	-4.640567E-02	-.0	-2.060955E-03	-.0	-2.707369E-03	-.0
30	8.793226E-16	-.0	-4.647219E-02	-.0	1.269097E-03	-.0	-1.605125E-03	-.0
31	7.949765E-16	-.0	-3.526491E-02	-.0	3.407256E-03	-.0	-1.073077E-03	-.0
32	-1.051525E-16	-.0	-2.680569E-02	-.0	3.560778E-03	-.0	-8.222394E-04	-.0
33	-6.253660E-16	-.0	-1.585924E-02	-.0	3.226906E-03	-.0	-4.934491E-04	-.0
34	-1.174425E-16	-.0	-8.629302E-03	-.0	2.876713E-03	-.0	1.986786E-04	-.0
35	2.678958E-16	-.0	-3.031664E-03	-.0	2.104023E-03	-.0	4.763200E-04	-.0
36	3.130183E-16	-.0	-7.380703E-04	-.0	8.935741E-04	-.0	3.632585E-04	-.0
37	-1.359441E-15	-.0	-1.749914E-03	-.0	6.192003E-03	-.0	-3.433619E-03	-.0
38	-2.240999E-15	-.0	4.509380E-05	-.0	6.225000E-03	-.0	-1.818685E-03	-.0
39	7.264234E-16	-.0	-1.712474E-03	-.0	7.865063E-04	-.0	-3.103438E-04	-.0
40	1.798023E-15	-.0	-1.114766E-02	-.0	-2.222910E-03	-.0	-2.151254E-04	-.0
41	3.744815E-17	-.0	-1.724683E-02	-.0	-8.521854E-04	-.0	-5.089491E-04	-.0
42	-2.063458E-15	-.0	-2.233296E-02	-.0	1.345741E-03	-.0	-1.223173E-03	-.0
43	-1.736855E-15	-.0	-2.122226E-02	-.0	1.964386E-03	-.0	-1.528667E-03	-.0
44	-1.034535E-15	-.0	-1.785892E-02	-.0	2.001165E-03	-.0	-1.366771E-03	-.0
45	-1.554712E-15	-.0	-1.198158E-02	-.0	2.548663E-03	-.0	-1.106684E-03	-.0

PRESSURE REPORT - COND 1

NASA TM X-2909 LEADING/TRAILING EDGE CONTROLS APR 12, 1975

REDUCED FREQUENCY .0000 MACH NO. .5000

[PROGRAM OUTPUT] = [P(LOWER)-P(UPPER)] / (.5*RHO*V**2) UNITS = (MODAL DISPLACEMENT UNITS)/(PLANFORM LENGTH UNITS)

CHORD NO.	Y-BAR	POINT NO.	XBAR	MODE 3 REAL	MODE 3 IMAG	MODE 3 AMPLITUDE	MODE 3 PHASE(DEG)	MODE 4 REAL	MODE 4 IMAG	MODE 4 AMPLITUDE	MODE 4 PHASE(DEG)
1	.010	1	-.990	-1.652E-01	.0	1.652E-01	180.000	4.857E-02	.0	4.857E-02	.000
		2	-.900	-4.252E-02	.0	4.252E-02	180.000	2.352E-02	.0	2.352E-02	.000
		3	-.800	-2.738E-02	.0	2.738E-02	180.000	1.998E-02	.0	1.998E-02	.000
		4	-.700	-1.784E-02	.0	1.784E-02	180.000	1.883E-02	.0	1.883E-02	.000
		5	-.600	-9.337E-03	.0	9.337E-03	180.000	1.951E-02	.0	1.951E-02	.000
		6	-.500	-5.302E-03	.0	5.302E-03	180.000	2.163E-02	.0	2.163E-02	.000
		7	-.400	-3.596E-03	.0	3.596E-03	180.000	2.470E-02	.0	2.470E-02	.000
		8	-.300	-3.069E-03	.0	3.069E-03	180.000	2.819E-02	.0	2.819E-02	.000
		9	-.200	-3.083E-03	.0	3.083E-03	180.000	3.164E-02	.0	3.164E-02	.000
		10	-.100	-3.282E-03	.0	3.282E-03	180.000	3.468E-02	.0	3.468E-02	.000
		11	.000	-3.480E-03	.0	3.480E-03	180.000	3.712E-02	.0	3.712E-02	.000
		12	.100	-3.587E-03	.0	3.587E-03	180.000	3.895E-02	.0	3.895E-02	.000
		13	.200	-3.551E-03	.0	3.551E-03	180.000	4.032E-02	.0	4.032E-02	.000
		14	.300	-3.329E-03	.0	3.329E-03	180.000	4.161E-02	.0	4.161E-02	.000
		15	.400	-2.866E-03	.0	2.866E-03	180.000	4.337E-02	.0	4.337E-02	.000
		16	.500	-2.108E-03	.0	2.108E-03	180.000	4.645E-02	.0	4.645E-02	.000
		17	.600	-1.022E-03	.0	1.022E-03	180.000	5.179E-02	.0	5.179E-02	.000
		18	.700	3.509E-04	.0	3.509E-04	.000	5.330E-02	.0	5.330E-02	.000
		19	.800	1.824E-03	.0	1.824E-03	.000	4.795E-02	.0	4.795E-02	.000
		20	.900	2.861E-03	.0	2.861E-03	.000	3.547E-02	.0	3.547E-02	.000
		21	.990	1.517E-03	.0	1.517E-03	.000	1.133E-02	.0	1.133E-02	.000
2	.100	1	-.990	-8.860E-02	.0	8.860E-02	180.000	5.951E-02	.0	5.951E-02	.000
		2	-.900	-1.376E-02	.0	1.376E-02	180.000	2.804E-02	.0	2.804E-02	.000
		3	-.800	-9.332E-03	.0	9.332E-03	180.000	2.463E-02	.0	2.463E-02	.000
		4	-.700	-6.842E-03	.0	6.842E-03	180.000	2.383E-02	.0	2.383E-02	.000
		5	-.600	-3.086E-03	.0	3.086E-03	180.000	2.467E-02	.0	2.467E-02	.000
		6	-.500	-2.118E-03	.0	2.118E-03	180.000	2.678E-02	.0	2.678E-02	.000
		7	-.400	-1.997E-03	.0	1.997E-03	180.000	2.974E-02	.0	2.974E-02	.000
		8	-.300	-1.903E-03	.0	1.903E-03	180.000	3.313E-02	.0	3.313E-02	.000
		9	-.200	-1.583E-03	.0	1.583E-03	180.000	3.654E-02	.0	3.654E-02	.000
		10	-.100	-1.075E-03	.0	1.075E-03	180.000	3.963E-02	.0	3.963E-02	.000
		11	.000	-5.356E-04	.0	5.356E-04	180.000	4.216E-02	.0	4.216E-02	.000
		12	.100	-1.337E-04	.0	1.337E-04	180.000	4.402E-02	.0	4.402E-02	.000
		13	.200	2.403E-05	.0	2.403E-05	.000	4.522E-02	.0	4.522E-02	.000
		14	.300	-6.236E-05	.0	6.236E-05	180.000	4.596E-02	.0	4.596E-02	.000
		15	.400	-2.772E-04	.0	2.772E-04	180.000	4.664E-02	.0	4.664E-02	.000
		16	.500	-4.136E-04	.0	4.136E-04	180.000	4.797E-02	.0	4.797E-02	.000
		17	.600	-2.273E-04	.0	2.273E-04	180.000	5.087E-02	.0	5.087E-02	.000
		18	.700	4.822E-04	.0	4.822E-04	.000	4.927E-02	.0	4.927E-02	.000
		19	.800	1.734E-03	.0	1.734E-03	.000	4.065E-02	.0	4.065E-02	.000
		20	.900	3.031E-03	.0	3.031E-03	.000	2.630E-02	.0	2.630E-02	.000
		21	.990	1.801E-03	.0	1.801E-03	.000	6.896E-03	.0	6.896E-03	.000

3	.200	1	-.990	-4.481E-02	.0	4.481E-02	180.000	8.412E-02	.0	8.412E-02	.000
		2	-.900	-5.445E-03	.0	5.445E-03	180.000	3.738E-02	.0	3.738E-02	.000
		3	-.800	-6.172E-03	.0	6.172E-03	180.000	3.187E-02	.0	3.187E-02	.000
		4	-.700	-5.071E-03	.0	5.071E-03	180.000	3.008E-02	.0	3.008E-02	.000
		5	-.600	-1.434E-03	.0	1.434E-03	180.000	3.040E-02	.0	3.040E-02	.000
		6	-.500	-4.486E-04	.0	4.486E-04	180.000	3.230E-02	.0	3.230E-02	.000
		7	-.400	-2.810E-04	.0	2.810E-04	180.000	3.526E-02	.0	3.526E-02	.000
		8	-.300	-1.405E-04	.0	1.405E-04	180.000	3.878E-02	.0	3.878E-02	.000
		9	-.200	2.102E-04	.0	2.102E-04	.000	4.238E-02	.0	4.238E-02	.000
		10	-.100	7.182E-04	.0	7.182E-04	.000	4.564E-02	.0	4.564E-02	.000
		11	.000	1.205E-03	.0	1.205E-03	.000	4.829E-02	.0	4.829E-02	.000
		12	.100	1.484E-03	.0	1.484E-03	.000	5.017E-02	.0	5.017E-02	.000
		13	.200	1.444E-03	.0	1.444E-03	.000	5.129E-02	.0	5.129E-02	.000
		14	.300	1.091E-03	.0	1.091E-03	.000	5.184E-02	.0	5.184E-02	.000
		15	.400	5.426E-04	.0	5.426E-04	.000	5.224E-02	.0	5.224E-02	.000
		16	.500	-1.224E-05	.0	1.224E-05	180.000	5.320E-02	.0	5.320E-02	.000
		17	.600	-3.587E-04	.0	3.587E-04	180.000	5.570E-02	.0	5.570E-02	.000
		18	.700	-3.064E-04	.0	3.064E-04	180.000	5.330E-02	.0	5.330E-02	.000
		19	.800	2.361E-04	.0	2.361E-04	.000	4.342E-02	.0	4.342E-02	.000
		20	.900	1.071E-03	.0	1.071E-03	.000	2.760E-02	.0	2.760E-02	.000
		21	.990	8.210E-04	.0	8.210E-04	.000	7.046E-03	.0	7.046E-03	.000
4	.300	1	-.990	-4.872E-02	.0	4.872E-02	180.000	1.169E-01	.0	1.169E-01	.000
		2	-.900	-5.680E-03	.0	5.680E-03	180.000	4.909E-02	.0	4.909E-02	.000
		3	-.800	-5.343E-03	.0	5.343E-03	180.000	4.066E-02	.0	4.066E-02	.000
		4	-.700	-3.030E-03	.0	3.030E-03	180.000	3.766E-02	.0	3.766E-02	.000
		5	-.600	1.772E-03	.0	1.772E-03	.000	3.751E-02	.0	3.751E-02	.000
		6	-.500	3.274E-03	.0	3.274E-03	.000	3.939E-02	.0	3.939E-02	.000
		7	-.400	3.555E-03	.0	3.555E-03	.000	4.262E-02	.0	4.262E-02	.000
		8	-.300	3.551E-03	.0	3.551E-03	.000	4.656E-02	.0	4.656E-02	.000
		9	-.200	3.569E-03	.0	3.569E-03	.000	5.063E-02	.0	5.063E-02	.000
		10	-.100	3.578E-03	.0	3.578E-03	.000	5.438E-02	.0	5.438E-02	.000
		11	.000	3.417E-03	.0	3.417E-03	.000	5.750E-02	.0	5.750E-02	.000
		12	.100	2.953E-03	.0	2.953E-03	.000	5.984E-02	.0	5.984E-02	.000
		13	.200	2.170E-03	.0	2.170E-03	.000	6.145E-02	.0	6.145E-02	.000
		14	.300	1.168E-03	.0	1.168E-03	.000	6.257E-02	.0	6.257E-02	.000
		15	.400	1.050E-04	.0	1.050E-04	.000	6.364E-02	.0	6.364E-02	.000
		16	.500	-8.706E-04	.0	8.706E-04	180.000	6.539E-02	.0	6.539E-02	.000
		17	.600	-1.631E-03	.0	1.631E-03	180.000	6.873E-02	.0	6.873E-02	.000
		18	.700	-2.056E-03	.0	2.056E-03	180.000	6.640E-02	.0	6.640E-02	.000
		19	.800	-2.018E-03	.0	2.018E-03	180.000	5.524E-02	.0	5.524E-02	.000
		20	.900	-1.414E-03	.0	1.414E-03	180.000	3.650E-02	.0	3.650E-02	.000
		21	.990	-3.293E-04	.0	3.293E-04	180.000	9.982E-03	.0	9.982E-03	.000
5	.400	1	-.990	-2.796E-02	.0	2.796E-02	180.000	1.575E-01	.0	1.575E-01	.000
		2	-.900	5.684E-03	.0	5.684E-03	.000	6.441E-02	.0	6.441E-02	.000
		3	-.800	2.744E-03	.0	2.744E-03	.000	5.256E-02	.0	5.256E-02	.000
		4	-.700	3.121E-03	.0	3.121E-03	.000	4.808E-02	.0	4.808E-02	.000
		5	-.600	7.242E-03	.0	7.242E-03	.000	4.738E-02	.0	4.738E-02	.000
		6	-.500	8.336E-03	.0	8.336E-03	.000	4.933E-02	.0	4.933E-02	.000
		7	-.400	8.521E-03	.0	8.521E-03	.000	5.310E-02	.0	5.310E-02	.000
		8	-.300	8.509E-03	.0	8.509E-03	.000	5.792E-02	.0	5.792E-02	.000
		9	-.200	8.264E-03	.0	8.264E-03	.000	6.313E-02	.0	6.313E-02	.000
		10	-.100	7.478E-03	.0	7.478E-03	.000	6.817E-02	.0	6.817E-02	.000
		11	.000	5.949E-03	.0	5.949E-03	.000	7.269E-02	.0	7.269E-02	.000
		12	.100	3.778E-03	.0	3.778E-03	.000	7.653E-02	.0	7.653E-02	.000

		13	.200	1.311E-03	.0	1.311E-03	.000	7.973E-02	.0	7.973E-02	.000
		14	.300	-1.074E-03	.0	1.074E-03	180.000	8.248E-02	.0	8.248E-02	.000
		15	.400	-3.114E-03	.0	3.114E-03	180.000	8.516E-02	.0	8.516E-02	.000
		16	.500	-4.662E-03	.0	4.662E-03	180.000	8.831E-02	.0	8.831E-02	.000
		17	.600	-5.595E-03	.0	5.595E-03	180.000	9.259E-02	.0	9.259E-02	.000
		18	.700	-5.745E-03	.0	5.745E-03	180.000	8.910E-02	.0	8.910E-02	.000
		19	.800	-4.916E-03	.0	4.916E-03	180.000	7.388E-02	.0	7.388E-02	.000
		20	.900	-3.013E-03	.0	3.013E-03	180.000	4.849E-02	.0	4.849E-02	.000
		21	.990	-5.568E-04	.0	5.568E-04	180.000	1.312E-02	.0	1.312E-02	.000
6	.500	1	-.990	-1.541E-02	.0	1.541E-02	180.000	2.125E-01	.0	2.125E-01	.000
		2	-.900	1.019E-02	.0	1.019E-02	.000	8.666E-02	.0	8.666E-02	.000
		3	-.800	7.725E-03	.0	7.725E-03	.000	6.977E-02	.0	6.977E-02	.000
		4	-.700	1.100E-02	.0	1.100E-02	.000	6.304E-02	.0	6.304E-02	.000
		5	-.600	1.899E-02	.0	1.899E-02	.000	6.175E-02	.0	6.175E-02	.000
		6	-.500	2.253E-02	.0	2.253E-02	.000	6.439E-02	.0	6.439E-02	.000
		7	-.400	2.335E-02	.0	2.335E-02	.000	6.976E-02	.0	6.976E-02	.000
		8	-.300	2.159E-02	.0	2.159E-02	.000	7.679E-02	.0	7.679E-02	.000
		9	-.200	1.705E-02	.0	1.705E-02	.000	8.455E-02	.0	8.455E-02	.000
		10	-.100	1.032E-02	.0	1.032E-02	.000	9.236E-02	.0	9.236E-02	.000
		11	.000	2.914E-03	.0	2.914E-03	.000	9.983E-02	.0	9.983E-02	.000
		12	.100	-3.553E-03	.0	3.553E-03	180.000	1.069E-01	.0	1.069E-01	.000
		13	.200	-8.197E-03	.0	8.197E-03	180.000	1.138E-01	.0	1.138E-01	.000
		14	.300	-1.096E-02	.0	1.096E-02	180.000	1.208E-01	.0	1.208E-01	.000
		15	.400	-1.225E-02	.0	1.225E-02	180.000	1.284E-01	.0	1.284E-01	.000
		16	.500	-1.249E-02	.0	1.249E-02	180.000	1.367E-01	.0	1.367E-01	.000
		17	.600	-1.192E-02	.0	1.192E-02	180.000	1.455E-01	.0	1.455E-01	.000
		18	.700	-1.056E-02	.0	1.056E-02	180.000	1.422E-01	.0	1.422E-01	.000
		19	.800	-8.291E-03	.0	8.291E-03	180.000	1.206E-01	.0	1.206E-01	.000
		20	.900	-5.009E-03	.0	5.009E-03	180.000	8.205E-02	.0	8.205E-02	.000
		21	.990	-1.084E-03	.0	1.084E-03	180.000	2.361E-02	.0	2.361E-02	.000
7	.600	1	-.990	3.715E-02	.0	3.715E-02	.000	2.905E-01	.0	2.905E-01	.000
		2	-.900	4.229E-02	.0	4.229E-02	.000	1.228E-01	.0	1.228E-01	.000
		3	-.800	4.195E-02	.0	4.195E-02	.000	9.807E-02	.0	9.807E-02	.000
		4	-.700	5.236E-02	.0	5.236E-02	.000	8.723E-02	.0	8.723E-02	.000
		5	-.600	6.818E-02	.0	6.818E-02	.000	8.487E-02	.0	8.487E-02	.000
		6	-.500	6.999E-02	.0	6.999E-02	.000	8.905E-02	.0	8.905E-02	.000
		7	-.400	5.528E-02	.0	5.528E-02	.000	9.798E-02	.0	9.798E-02	.000
		8	-.300	2.834E-02	.0	2.834E-02	.000	1.099E-01	.0	1.099E-01	.000
		9	-.200	7.094E-05	.0	7.094E-05	.000	1.235E-01	.0	1.235E-01	.000
		10	-.100	-2.093E-02	.0	2.093E-02	180.000	1.376E-01	.0	1.376E-01	.000
		11	.000	-3.259E-02	.0	3.259E-02	180.000	1.522E-01	.0	1.522E-01	.000
		12	.100	-3.672E-02	.0	3.672E-02	180.000	1.675E-01	.0	1.675E-01	.000
		13	.200	-3.603E-02	.0	3.603E-02	180.000	1.847E-01	.0	1.847E-01	.000
		14	.300	-3.285E-02	.0	3.285E-02	180.000	2.049E-01	.0	2.049E-01	.000
		15	.400	-2.873E-02	.0	2.873E-02	180.000	2.292E-01	.0	2.292E-01	.000
		16	.500	-2.448E-02	.0	2.448E-02	180.000	2.561E-01	.0	2.561E-01	.000
		17	.600	-2.033E-02	.0	2.033E-02	180.000	2.807E-01	.0	2.807E-01	.000
		18	.700	-1.619E-02	.0	1.619E-02	180.000	2.772E-01	.0	2.772E-01	.000
		19	.800	-1.182E-02	.0	1.182E-02	180.000	2.339E-01	.0	2.339E-01	.000
		20	.900	-6.991E-03	.0	6.991E-03	180.000	1.580E-01	.0	1.580E-01	.000
		21	.990	-1.650E-03	.0	1.650E-03	180.000	4.612E-02	.0	4.612E-02	.000
8	.700	1	-.990	3.226E-01	.0	3.226E-01	.000	4.259E-01	.0	4.259E-01	.000
		2	-.900	4.057E-01	.0	4.057E-01	.000	1.860E-01	.0	1.860E-01	.000

		3	-.800	4.996E-01	.0	4.996E-01	.000	1.467E-01	.0	1.467E-01	.000
		4	-.700	3.413E-01	.0	3.413E-01	.000	1.287E-01	.0	1.287E-01	.000
		5	-.600	4.178E-02	.0	4.178E-02	.000	1.254E-01	.0	1.254E-01	.000
		6	-.500	-1.479E-01	.0	1.479E-01	180.000	1.341E-01	.0	1.341E-01	.000
		7	-.400	-1.843E-01	.0	1.843E-01	180.000	1.515E-01	.0	1.515E-01	.000
		8	-.300	-1.813E-01	.0	1.813E-01	180.000	1.747E-01	.0	1.747E-01	.000
		9	-.200	-1.650E-01	.0	1.650E-01	180.000	2.012E-01	.0	2.012E-01	.000
		10	-.100	-1.420E-01	.0	1.420E-01	180.000	2.302E-01	.0	2.302E-01	.000
		11	.000	-1.165E-01	.0	1.165E-01	180.000	2.627E-01	.0	2.627E-01	.000
		12	.100	-9.228E-02	.0	9.228E-02	180.000	3.024E-01	.0	3.024E-01	.000
		13	.200	-7.155E-02	.0	7.155E-02	180.000	3.567E-01	.0	3.567E-01	.000
		14	.300	-5.492E-02	.0	5.492E-02	180.000	4.378E-01	.0	4.378E-01	.000
		15	.400	-4.205E-02	.0	4.205E-02	180.000	5.662E-01	.0	5.662E-01	.000
		16	.500	-3.226E-02	.0	3.226E-02	180.000	7.687E-01	.0	7.687E-01	.000
		17	.600	-2.481E-02	.0	2.481E-02	180.000	9.880E-01	.0	9.880E-01	.000
		18	.700	-1.898E-02	.0	1.898E-02	180.000	8.639E-01	.0	8.639E-01	.000
		19	.800	-1.402E-02	.0	1.402E-02	180.000	5.928E-01	.0	5.928E-01	.000
		20	.900	-9.076E-03	.0	9.076E-03	180.000	3.483E-01	.0	3.483E-01	.000
		21	.990	-2.617E-03	.0	2.617E-03	180.000	9.675E-02	.0	9.675E-02	.000
9	.800	1	-.990	8.820E+00	.0	8.820E+00	.000	7.124E-01	.0	7.124E-01	.000
		2	-.900	2.095E+00	.0	2.095E+00	.000	2.931E-01	.0	2.931E-01	.000
		3	-.800	4.816E-01	.0	4.816E-01	.000	2.351E-01	.0	2.351E-01	.000
		4	-.700	-1.006E+00	.0	1.006E+00	180.000	2.131E-01	.0	2.131E-01	.000
		5	-.600	-2.077E+00	.0	2.077E+00	180.000	2.121E-01	.0	2.121E-01	.000
		6	-.500	-1.015E+00	.0	1.015E+00	180.000	2.273E-01	.0	2.273E-01	.000
		7	-.400	-6.135E-01	.0	6.135E-01	180.000	2.550E-01	.0	2.550E-01	.000
		8	-.300	-3.702E-01	.0	3.702E-01	180.000	2.923E-01	.0	2.923E-01	.000
		9	-.200	-2.308E-01	.0	2.308E-01	180.000	3.380E-01	.0	3.380E-01	.000
		10	-.100	-1.523E-01	.0	1.523E-01	180.000	3.932E-01	.0	3.932E-01	.000
		11	.000	-1.048E-01	.0	1.048E-01	180.000	4.634E-01	.0	4.634E-01	.000
		12	.100	-7.405E-02	.0	7.405E-02	180.000	5.605E-01	.0	5.605E-01	.000
		13	.200	-5.345E-02	.0	5.345E-02	180.000	7.081E-01	.0	7.081E-01	.000
		14	.300	-3.977E-02	.0	3.977E-02	180.000	9.540E-01	.0	9.540E-01	.000
		15	.400	-3.103E-02	.0	3.103E-02	180.000	1.408E+00	.0	1.408E+00	.000
		16	.500	-2.561E-02	.0	2.561E-02	180.000	2.435E+00	.0	2.435E+00	.000
		17	.600	-2.185E-02	.0	2.185E-02	180.000	4.275E+00	.0	4.275E+00	.000
		18	.700	-1.806E-02	.0	1.806E-02	180.000	1.699E+00	.0	1.699E+00	.000
		19	.800	-1.279E-02	.0	1.279E-02	180.000	8.833E-01	.0	8.833E-01	.000
		20	.900	-5.526E-03	.0	5.526E-03	180.000	4.409E-01	.0	4.409E-01	.000
		21	.990	2.433E-04	.0	2.433E-04	.000	1.094E-01	.0	1.094E-01	.000
10	.900	1	-.990	8.589E-01	.0	8.589E-01	.000	1.330E+00	.0	1.330E+00	.000
		2	-.900	2.379E-01	.0	2.379E-01	.000	4.806E-01	.0	4.806E-01	.000
		3	-.800	1.063E-01	.0	1.063E-01	.000	3.840E-01	.0	3.840E-01	.000
		4	-.700	3.708E-02	.0	3.708E-02	.000	3.521E-01	.0	3.521E-01	.000
		5	-.600	3.912E-03	.0	3.912E-03	.000	3.433E-01	.0	3.433E-01	.000
		6	-.500	-8.746E-03	.0	8.746E-03	180.000	3.471E-01	.0	3.471E-01	.000
		7	-.400	-1.965E-02	.0	1.965E-02	180.000	3.594E-01	.0	3.594E-01	.000
		8	-.300	-2.725E-02	.0	2.725E-02	180.000	3.778E-01	.0	3.778E-01	.000
		9	-.200	-3.087E-02	.0	3.087E-02	180.000	4.008E-01	.0	4.008E-01	.000
		10	-.100	-3.093E-02	.0	3.093E-02	180.000	4.274E-01	.0	4.274E-01	.000
		11	.000	-2.840E-02	.0	2.840E-02	180.000	4.564E-01	.0	4.564E-01	.000
		12	.100	-2.447E-02	.0	2.447E-02	180.000	4.863E-01	.0	4.863E-01	.000
		13	.200	-2.022E-02	.0	2.022E-02	180.000	5.139E-01	.0	5.139E-01	.000
		14	.300	-1.646E-02	.0	1.646E-02	180.000	5.334E-01	.0	5.334E-01	.000

		15	.400	-1.364E-02	.0	1.364E-02	180.000	5.363E-01	.0	5.363E-01	.000
		16	.500	-1.174E-02	.0	1.174E-02	180.000	5.158E-01	.0	5.158E-01	.000
		17	.600	-1.034E-02	.0	1.034E-02	180.000	4.741E-01	.0	4.741E-01	.000
		18	.700	-8.747E-03	.0	8.747E-03	180.000	3.984E-01	.0	3.984E-01	.000
		19	.800	-6.192E-03	.0	6.192E-03	180.000	2.975E-01	.0	2.975E-01	.000
		20	.900	-2.405E-03	.0	2.405E-03	180.000	1.845E-01	.0	1.845E-01	.000
		21	.990	4.197E-04	.0	4.197E-04	.000	5.051E-02	.0	5.051E-02	.000
11	.990	1	-.990	-1.670E-01	.0	1.670E-01	180.000	1.823E+00	.0	1.823E+00	.000
		2	-.900	1.177E-01	.0	1.177E-01	.000	4.347E-01	.0	4.347E-01	.000
		3	-.800	1.445E-01	.0	1.445E-01	.000	2.435E-01	.0	2.435E-01	.000
		4	-.700	1.282E-01	.0	1.282E-01	.000	1.726E-01	.0	1.726E-01	.000
		5	-.600	1.015E-01	.0	1.015E-01	.000	1.399E-01	.0	1.399E-01	.000
		6	-.500	7.507E-02	.0	7.507E-02	.000	1.228E-01	.0	1.228E-01	.000
		7	-.400	5.003E-02	.0	5.003E-02	.000	1.126E-01	.0	1.126E-01	.000
		8	-.300	2.924E-02	.0	2.924E-02	.000	1.058E-01	.0	1.058E-01	.000
		9	-.200	1.376E-02	.0	1.376E-02	.000	1.007E-01	.0	1.007E-01	.000
		10	-.100	3.455E-03	.0	3.455E-03	.000	9.680E-02	.0	9.680E-02	.000
		11	.000	-2.431E-03	.0	2.431E-03	180.000	9.360E-02	.0	9.360E-02	.000
		12	.100	-4.954E-03	.0	4.954E-03	180.000	9.078E-02	.0	9.078E-02	.000
		13	.200	-5.236E-03	.0	5.236E-03	180.000	8.781E-02	.0	8.781E-02	.000
		14	.300	-4.308E-03	.0	4.308E-03	180.000	8.399E-02	.0	8.399E-02	.000
		15	.400	-3.001E-03	.0	3.001E-03	180.000	7.858E-02	.0	7.858E-02	.000
		16	.500	-1.880E-03	.0	1.880E-03	180.000	7.103E-02	.0	7.103E-02	.000
		17	.600	-1.220E-03	.0	1.220E-03	180.000	6.111E-02	.0	6.111E-02	.000
		18	.700	-1.008E-03	.0	1.008E-03	180.000	4.270E-02	.0	4.270E-02	.000
		19	.800	-9.961E-04	.0	9.961E-04	180.000	1.594E-02	.0	1.594E-02	.000
		20	.900	-8.055E-04	.0	8.055E-04	180.000	-1.128E-02	.0	1.128E-02	180.000
		21	.990	-1.994E-04	.0	1.994E-04	180.000	-1.301E-02	.0	1.301E-02	180.000

S E C T I O N A L   G E N E R A L I Z E D   F O R C E   M A T R I X - C O N D 1

C H O R D   N O . 9   Y =   1.0160   Y/S = .800

N A S A   T M   X - 2 9 0 9   LEADING/TRAILING EDGE CONTROLS   APR 12, 1975

REDUCED FREQUENCY   .0000   MACH NO. .5000

[PROGRAM OUTPUT] = QS(I-DEFL.,J-PRESS.) / (.5*RHO*V**2)   UNITS = (MODAL DISPLACEMENT UNITS)**2

	REAL	IMAG	REAL	IMAG	REAL	IMAG	REAL	IMAG
ROW 1	-1.873769E-14	.0	2.257511E+00	.0	8.525730E-03	.0	4.514282E-01	.0
	4.599539E-01	.0						
ROW 2	1.533342E-14	.0	-1.055498E+00	.0	1.725889E-02	.0	-3.193715E-01	.0
	-3.021126E-01	.0						
ROW 3	2.016198E-17	.0	8.426141E-02	.0	1.421762E-02	.0	1.780685E-03	.0
	1.599831E-02	.0						
ROW 4	9.961716E-16	.0	-2.250687E-03	.0	5.095434E-05	.0	-4.582757E-03	.0
	-4.531803E-03	.0						
ROW 5	1.016334E-15	.0	8.201073E-02	.0	1.426858E-02	.0	-2.802072E-03	.0
	1.146651E-02	.0						

G E N E R A L I Z E D   F O R C E   M A T R I X - C O N D 1

N A S A   T M   X - 2 9 0 9   LEADING/TRAILING EDGE CONTROLS   APR 12, 1975

REDUCED FREQUENCY   .0000   MACH NO.   .5000

(PROGRAM OUTPUT) = Q(I-DEFL.,J-PRESS.) / (.5*RHO*V**2)   UNITS = (PLANFORM LENGTH UNITS)*(MODAL DISPLACEMENT UNITS)**2

	REAL	IMAG	REAL	IMAG	REAL	IMAG	REAL	IMAG
ROW 1	-7.010056E-16	.0	3.865747E+00	.0	1.219203E-03	.0	1.824815E-01	.0
	1.837007E-01	.0						
ROW 2	4.253990E-15	.0	-2.134055E-01	.0	2.521867E-03	.0	-1.006528E-01	.0
	-9.813095E-02	.0						
ROW 3	6.022964E-18	.0	1.258624E-02	.0	1.912714E-03	.0	2.529597E-04	.0
	2.165674E-03	.0						
ROW 4	1.414889E-16	.0	-3.742066E-04	.0	8.984013E-06	.0	-6.983280E-04	.0
	-6.893440E-04	.0						
ROW 5	1.475119E-16	.0	1.221204E-02	.0	1.921698E-03	.0	-4.453684E-04	.0
	1.476330E-03	.0						

C - M A T R I X   F I L E   I N D E X   S U M M A R Y

N A S A   T M   X - 2 9 0 9   LEADING/TRAILING EDGE CONTROLS   APR 12, 1975

NUMBER OF C-MATRICES = 3   INITIAL CREATION DATE - 04/12/75   LAST MODIFICATION DATE - 04/12/75

NO. = MAIN SURFACE ENTRY NO.(LETTER FOR ASS. CONTROL ENTRY)
LOC = MATRIX LOCATION WITHIN FILE CMF1 OF CMFILE
ID. = SURFACE ID (CONTROL ID IS FOLLOWED BY CONTROL TYPE)

N1 = SYMMETRY, 0-SYM., 1-ANTISYM. * S = PLANFORM SEMI-SPAN
N2 = NO. DOWNWASH CHORDS * K/BO = REDUCED FREQUENCY/REFERENCE LENGTH
N3 = NO. POINTS/DOWNWASH CHORD * MACH = MACH NUMBER
N4 = NO. SPANWISE PRESSURE TERMS * DATE = DATE OF ENTRY
N5 = NO. CHORDWISE PRESSURE TERMS * TITLE = FIRST 65 CHARACTERS OF TITLE OF ENTRY RUN

NO.	LOC	ID.	N1	N2	N3	N4	N5	S	K/BO	MACH	DATE	TITLE
1	1	7000	0	12	6	12	6	1.2700	.0000	.5000	04/12/75	N A S A T M X - 2 9 0 9 LEADING/TRAILING EDGE CONTROLS
A	2	LECS	PARTIAL L.E.									
B	3	TECS	PARTIAL T.E.									

RHOIV EXECUTION STATISTICS APR 12, 1975

NASA TM X-2909 LEADING/TRAILING EDGE CONTROLS

MAXIMUM FIELD LENGTH REQUIRED 102400 OCTAL
CENTRAL PROCESSOR TIME REQUIRED 1102.569 SECONDS

SECTION	CP SECS.	NO. ENTRIES
INPUT PREPARATION	.493	1
MODAL INPUT PREPARATION	.104	1
RESULTS PREPARATION	5.737	1
C-MATRIX LIBRARY UTILIZATION		4
C-MATRIX CALCULATION		
(1) MAIN SURFACE, K=0	96.469	1
(2) MAIN SURFACE, K≠0	.000	0
(3) CONTROL SURFACE, K=0	977.861	2
(4) CONTROL SURFACE, K≠0	.000	0
	1074.335	3
SOLUTION FOR COEFFICIENTS		1
CALCULATION OF RESULTS		1

4.0 COMPUTER PROGRAM DESCRIPTION

This section is a description of the organization and function of the various routines included in the RHOIV package.

4.1 OVERLAY STRUCTURE

The RHOIV program consists of a (0,0) level overlay, a primary level overlay, and several secondary level overlays.

The (0,0) overlay, program ZRHOIV, is trivial consisting only of a loop on a call to the primary. Any other (0,0) level overlay could be substituted for ZRHO10 with the requirement that blank common not be mentioned.

The primary level (1,0) overlay, program RHOIV, is the driver for the RHOIV system, figure 6. Secondary level overlays are selected by RHOIV to perform a logical step in the users analysis.

The overlay structure is:

(1) (RHOIV,0,0) ZRHOIV, Calls overlay (RHOIV,1,0)

(2) (RHOIV,1,0) RHOIV, Calls secondary level overlays to read input, prepare data, calculate results

(3) (RHOIV,1,1) INPREP, Reads and checks all user input

(RHOIV,1,2) MIPREP, Processes modal input to allow for interpolation and calculation of control rotations.

(RHOIV,1,3) RESPREP, Prepares the basic downwash matrix, and any result information that can be calculated prior to the condition cycle.

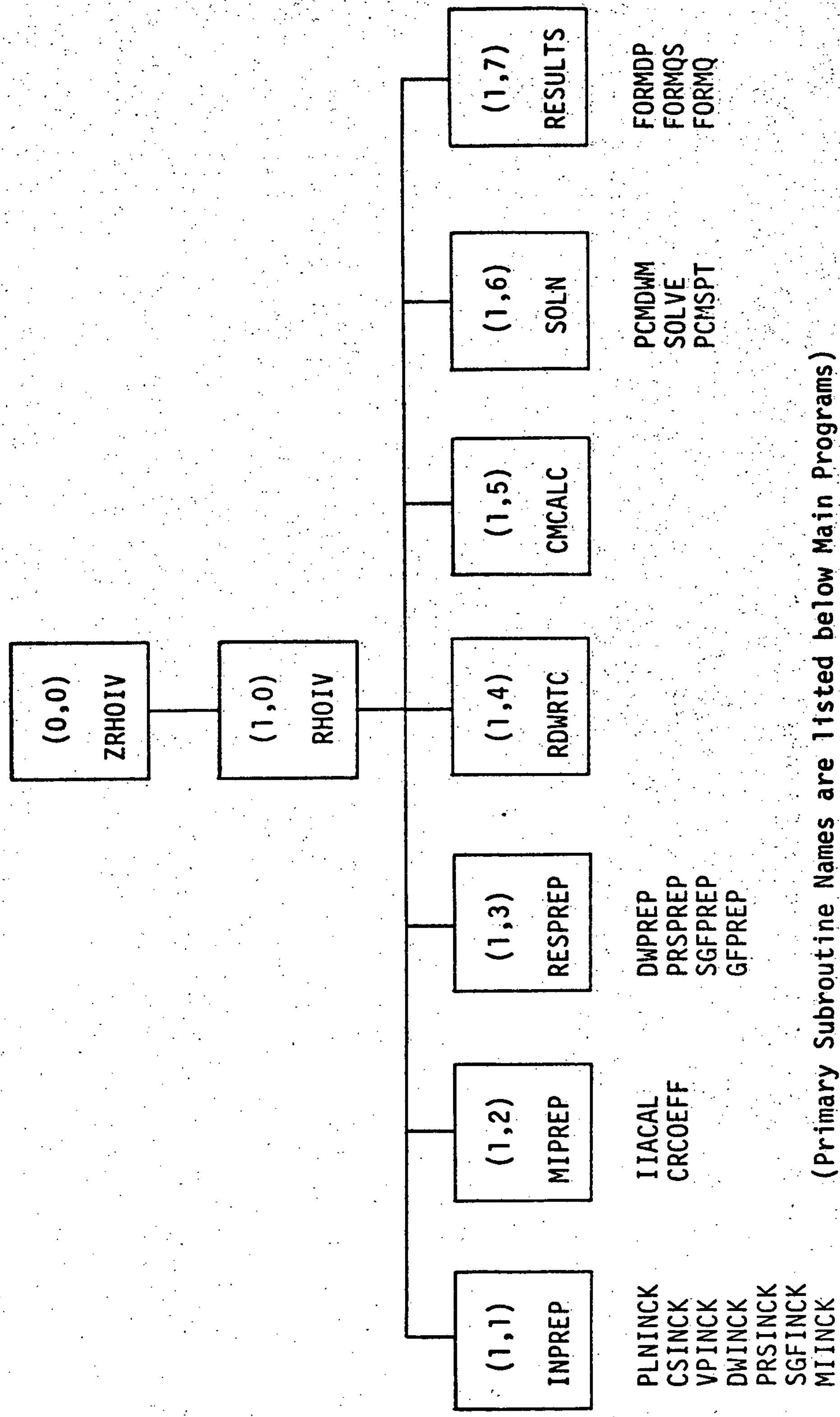
(RHOIV,1,4) RDWRTC, Performs all I/O and library work associated with a user C-matrix file.

(RHOIV,1,5) CMCALC, Calculates C-matrices for main surface or control surface pressure terms for a particular condition.

RHOIV,1,6) SOLN, Prints intermediate results and solves for the unknown coefficients of main surface pressure terms for a particular condition.

(RHOIV,1,7) RESULTS, Calculates all unsteady pressures,

sectional and total generalized forces using the information produced in RESPREP and SOLN.



OVERLAY STRUCTURE

FIGURE 6

4.2 COMMON BLOCK USAGE

The RHOIV program uses both BLANK and LABELED common.

The LABELED common blocks are used for communication between the primary and secondary overlays, and for communication between routines in a secondary overlay. The block names and contents are described on the following pages.

The T heading on the following pages refers to variable type: I - Integer, R - Real, C - Complex, L - Logical, H - Hollerith.

BLANK common is used in most secondary overlays as a variable length working area. In general the program of a overlay calculates the area required for arrays in the various subroutines and passes a dimension and first word address of each array through the subroutine calling sequence. A description of the area used by each overlay is given in section 3.3.

LABELED COMMON NAME: BASIC				LOAD LEVEL: PRIMARY (1,0)	
DESCRIPTION: Basic information, used by all modules.					

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	INDCM	I			C-MATRIX CALCULATION INDICATOR, 0-MAIN SURFACE, >0-CONTROL SURFACE
2	SYM	I			ANALYSIS SYMMETRY INDICATOR 1-SYMMETRIC 2-ANTISYMMETRIC
3	B0	R		b_0	REDUCED FREQUENCY REFERENCE LENGTH
4	S	R		S	PLANFORM SEMI-SPAN
5	YROOT	R			Y VALUE OF PLANFORM ROOT STATION
6	KVAL	R		$k = \omega/V$	K-VALUE, REDUCED FREQUENCY
7	KVALR	R		$k_r = b_0\omega/V$	REFERENCE K-VALUE
8	KSQD	R		k^2	
9	MACH	R		M	MACH NO.
10	BETA	R		$\beta = \sqrt{1-M^2}$	
11	BETASQD	R		β^2	
12	RTITLE	I	9		USER RUN TITLE, WITH DATE APPENDED

LABELED COMMON NAME: CMLIB					LOAD LEVEL: PRIMARY (1,0)
DESCRIPTION: Variables describing the contents of CMFILE are maintained in CMLIB during the condition cycle.					
NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	FINDCM	L			INDICATOR TO SEARCH FOR A C-MATRIX
2	CMFOUND	L			INDICATOR FOR C-MATRIX FOUND
3	IDNAME	I			INDEX MATRIX NAME = 10HCMFIL INDEX ON WRITE, CHECKED ON READ
4	NOCM	I			NUMBER OF C-MATRICES ON CMFILE
5	NMSNTRY	I			NUMBER OF MAIN SURFACE ENTRIES IN INDEX, (=NO. MAIN SURFACE C-MATRICES ON CMFILE)
6	CDATE	I			LIBRARY CREATION DATE
7	LMDATE	I			LAST DATE C-MATRICES ADDED
8	LINDEX	I			LENGTH OF CMFILE INDEX
9	MSENTRY	I			POSITION WITHIN INDEX OF A MAIN SURFACE ENTRY
10	NCSE	I			NUMBER OF CONTROL SURFACE ENTRIES ASSOCIATED WITH A MAIN SURFACE ENTRY
11	MATPOS	I			MATRIX POSITION WITHIN CMFILE
12	DATE	I			CURRENT DATE

LABELED COMMON NAME: CMVAL				LOAD LEVEL: SECONDARY (1,5)	
DESCRIPTION: Used by most C-Matrix routines.					
NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	ROWC	C	(72,8)	C	ROWS OF C-MATRIX ASSOCIATED WITH DOWNWASH POINTS ON CHORD
2	GXYY	C	(72,8)	G(x,y,y)	SUBTRACTION TERMS ASSOCIATED WITH EVALUATION OF DIPOLE SINGULARITY
3	GPXYY	C	(72,8)	G'(x,y,y)	
4	CIPK	C	16		CHORDWISE INTEGRAL OF PRESSURE TERMS TIMES KERNEL
5	KERN	C		$K(x_0,y_0,k,M)$	KERNEL FUNCTION VALUE

LABELED COMMON NAME:		COND		LOAD LEVEL: PRIMARY (1,0)	
NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	NOKVAL	I			NUMBER OF K-VALUES, REDUCED FREQUENCIES
2	KVALUES	R	20		K-VALUES
3	NOMACH	I			NUMBER OF MACH NUMBERS
4	MACHNO	R	20		MACH NUMBERS

LABELED COMMON NAME:	COUNT	LOAD LEVEL: PRIMARY (1,0)

DESCRIPTION: Miscellaneous counters used during condition cycle to size working storage.

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	NSPT	I			NUMBER OF SPANWISE MAIN SURFACE PRESSURE TERMS
2	NCPT	I			NUMBER OF CHORDWISE MAIN SURFACE PRESSURE TERMS
3	NPTRM	I			TOTAL NUMBER OF ASSUMED MAIN SURFACE PRESSURE TERMS
4	NDMDS	I			NUMBER OF DISPLACEMENT MODES
5	NPMDS	I			NUMBER OF PRESSURE MODES (NOTE, EXCEPT IN THE CASE OF A GUST ANALYSIS, NDMDS=NPMDS. FOR A GUST ANALYSIS NPMDS=NDMDS+1.)
6	NZONES	I			NUMBER OF MODAL INPUT ZONES
7	MIPTS	I			MAXIMUM NUMBER OF INPUT POINTS IN ANY MODAL INPUT ZONE
8	MIPSGF	I			MAXIMUM NUMBER OF QUADRATURE POINTS REQUIRED FOR CHORDWISE INTEGRATION FOR ANY SECTIONAL FORCE OUTPUT CHORD.
9	MICGF	I			MAXIMUM NUMBER OF QUADRATURE CHORD REQUIRED FOR SPANWISE INTEGRATION FOR TOTAL GENERAL. FORCES.
10	MIPGF	I			MAXIMUM NUMBER OF QUADRATURE POINTS REQUIRED FOR CHORDWISE INTEGRATION ALONG ANY QUADRATURE CHORD FOR TOTAL GENERALIZED FORCES.
11	NOVP	I			NUMBER OF VELOCITY PROFILES
12	LOCVP	I			LOCATION OF VELOCITY PROFILE INFORMATION IN BLANK COMMON

13	NPRC	I			NUMBER OF PRESSURE REPORT CHORDS
14	NPPRC	I			NUMBER OF POINTS/PRESSURE REPORT CHORD
15	NPPT	I			TOTAL NO. PRESSURE OUTPUT POINTS
16	NSGFC	I			NUMBER OF SECTIONAL FORCE OUTPUT CHORDS.

LABELED COMMON NAME:	CQUAD	LOAD LEVEL:	SECONDARY (1,5/7)

DESCRIPTION: Used by CHDINT and Chordwise Quadrature routines in C-matrix calculation. DELXI is also used during sectional and total generalized force integration.

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	XILIL	R		ξ_L	ξ OF CHORDWISE INTEGRATION REGION LOWER LIMIT
2	XIUIL	R		ξ_U	ξ OF CHORDWISE INTEGRATION REGION UPPER LIMIT
3	DELXI	R		$\xi_U-\xi_L$	
4	XIMID	R		$(\xi_U+\xi_L)/2$	

LABELED COMMON NAME:		CSVAL		LOAD LEVEL: SECONDARY (1,1-3/5/7)	
DESCRIPTION:	Used by TETERM, DTETERM, LETERM, DLETERM, most terms generated by CSINIT.				

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	INDCS	I			INDICATOR FOR TYPE CONTROL SURFACE, 1-FULL, 2-TIP, 3-MID, 4-PARTIAL
2	LECS	L			INDICATOR FOR LEADING EDGE CONTROL, .T.=LEADING EDGE, .F.=TRAILING EDGE.
3	SYMSF	R		S_f	SYMMETRY SIGN FACTOR +1.0 - SYMMETRIC ANALYSIS -1.0 - ANTISYMMETRIC ANALYSIS
4	YCSI	R		y_i	INBOARD CONTROL SIDE EDGE
5	XHCSI	R		x_i	INBOARD CONTROL HINGE POINT
6	XLCSI	R			LEADING EDGE VALUE AT INBOARD CONTROL SIDE EDGE
7	YCSO	R		y_o	OUTBOARD CONTROL SIDE EDGE
8	XHCSO	R		x_o	OUTBOARD CONTROL HINGE POINT
9	XLCSO	R			LEADING EDGE VALUE AT OUT-BOARD CONTROL SIDE EDGE
10	DELYCS	R		y_o-y_i	CONTROL SPAN
11	TANLH	R		$\tan\Lambda_H$	TANGENT OF HINGE SWEEP ANGLE
12	BETAH	R		β_H	
13	BHSQD	R		β_H^2	
14	TANLL	R		$\tan\Lambda_L$	TANGENT OF LEADING EDGE SWEEP, FOR A LEADING EDGE CONTROL
15	BETAL	R		β_L	
16	BLSQD	R		β_L^2	
17	XIE1	R			PHYSICAL, OR CONSTANT PERCENT CHORD EXTENSION OF HINGE FOR

18	DXIE1E			$\partial XIE1/\partial\eta$	E1 FUNCTION IN TETERM

LABELED COMMON NAME: DWPTS				LOAD LEVEL: PRIMARY (1,0)	
DESCRIPTION: Used in INPREP, DWPREP, RDWRTC, and CMCALC					
NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	NDWC	I			NUMBER OF DOWNWASH CHORDS
2	YDWC	R	72	Y	DOWNWASH CHORDS, SPANWISE COORDINATE VALUES FOR DOWNWASH POINTS
3	NPDWC	I			NUMBER OF POINTS PER DOWNWASH CHORD
4	NDWP	I			TOTAL NUMBER OF DOWNWASH POINTS (=NDWC*NPDWC)
5	XDWP	R	72	X	DOWNWASH POINT STREAMWISE COORDINATE VALUES

LABELED COMMON NAME:		ENDIT		LOAD LEVEL: PRIMARY (1,0)	
DESCRIPTION:	Read in INPREP - used by RHOIV. Specifies termination procedure.				

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	LNAME	I			TERMINATION INDICATOR $= \left\{ \begin{array}{l} \text{BLANK} \\ \text{"EXIT"} \end{array} \right\}$ CALL EXIT = "RETURN", EXECUTE RETURN OTHERWISE CALL OVERLAY (LNAME,L1,L2,0)
2	L1	I			PRIMARY LEVEL OVERLAY NO.
3	L2	I			SECONDARY LEVEL OVERLAY NO.

LABELED COMMON NAME: FILES					LOAD LEVEL: PRIMARY (1,0)
DESCRIPTION: Defines all files used within the program.					
NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	MIFILE	I			MODAL INPUT FILE NAME
2	CMFILE	I			C-MATRIX FILE NAME
3	DPFILE	I			DELTA PRESSURE FILE NAME
4	SGFFILE	I			SECTIONAL FORCE FILE NAME
5	GFFILE	I			GENERALIZED FORCE FILE NAME NOTE 1-5 ARE USER ASSIGNED NAMES.
6	IN	I			STANDARD INPUT FILE NAME
7	OUT	I			STANDARD OUTPUT FILE NAME
8	RHOSC1 (MISFILE) (RESFILE)	I I I			SCRATCH FILE NO. 1 NAME MODAL INFORMATION SCRATCH FILE NAME, RESULT SCRATCH FILE NAME
9	RHOSC2 (INSFILE) (CMSFILE) (COFFILE)	I I I I			SCRATCH FILE NO. 2 NAME INPUT SCRATCH FILE NAME C-MATRIX SCRATCH FILE NAME COEFFICIENT FILE NAME
10	MIF1	I			INITIAL FILE POSITION OF MIFILE
11	CMF1	I			INITIAL FILE POSITION OF CMFILE
12	DPF1	I			INITIAL FILE POSITION OF DPFILE
13	SGFF1	I			INITIAL FILE POSITION OF SGFFILE
14	GFF1	I			INITIAL FILE POSITION OF GFFILE

LABELED COMMON NAME:	FILES			LOAD LEVEL: PRIMARY (1,0)	
DESCRIPTION: Field length control/utilization information.					
NO.	**VARIABLE**	**T**	**DIM.**	**ENG. NOM.**	**DESCRIPTION**
1	CURFL	I			CURRENT PROGRAM FIELD LENGTH
2	MAXFL	I			MAXIMUM PROGRAM FIELD LENGTH USED TO CURRENT TIME
3	INITL	I			INITIAL PROGRAM FIELD LENGTH
4	JOBFL	I			JOB CARD FIELD LENGTH (I.E., MAXIMUM ALLOWABLE FIELD LENGTH
5	INPFL	I			MINIMUM FL REQUIRED FOR INPREP
6	MIPFL	I			MINIMUM FL REQUIRED FOR MIPREP
7	RESPFL	I			MINIMUM FL REQUIRED FOR RESPREP
8	RWCFL	I			MINIMUM FL REQUIRED FOR RDWRTC
9	CMCFL	I			MINIMUM FL REQUIRED FOR CMCALC
10	SOLNFL	I			MINIMUM FL REQUIRED FOR SOLN
11	RESFL	I			MINIMUM FL REQUIRED FOR RESULTS
12	LIIA	I			LENGTH OF INTERPOLATION INFORMATION ARRAYS
13	LV	I			LENGTH OF VELOCITY PROFILE INFORMATION
14	LCCR	I			LENGTH OF CONTROL ROTATION COEFFICIENTS INFORMATION

LABELED COMMON NAME: KRNTERM				LOAD LEVEL: SECONDARY (1,5)	
DESCRIPTION: Used by kernel function routines.					
NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	FK	R		fk	ARBITRARY POINT FOR SPLITTING INTEGRAL IN ROSEL'S KERNEL FORMULATION ($FK=2\pi$)
2	FKSQD	R		$(fk)^2$	
3	RFKSKYS	R		$\sqrt{(fk)^2+(ky_o)^2}$	
4	HK	R		hk	UPPER INTEGRATION LIMIT
5	HKSQD	R		$(hk)^2$	
6	RHKSKYS	R		$\sqrt{(hk)^2+(ky_o)^2}$	
7	HOYO	R		h/y_o	
8	APROXR	R			$\left.\right\} \int_{-\infty}^{h}[\tau e^{iky_0\tau}/\sqrt{1+\tau^2}]d\tau$
9	APROXI	R			INTEGRAL APPROXIMATION IN WATKIN'S FORMULATION
10	S1R	R			$\left.\right\} \int_{-\infty}^{-kf}[e^{i\lambda}/\{\lambda^2+(ky_0)^2\}^{3/2}]d\lambda$
11	S1I	R			
12	S2R	R			$\left.\right\} \int_{-kf}^{kh}\frac{e^{i\lambda}-1-i\lambda+\lambda^2/2}{[\lambda^2+(ky_0)^2]^{3/2}}d\lambda$
13	S2I	R			
14	S3R	R			$\left.\right\} \int_{-\infty}^{kh}[e^{i\lambda}/\{\lambda^2+(ky_0)^2\}^{3/2}]d\lambda$
15	S3I	R			INTEGRALS IN ROSEL'S FORMULATION

LABELED COMMON NAME: KRNVAR	LOAD LEVEL: SECONDARY (1,5)
DESCRIPTION: Used by C-matrix chcrdwise quadrature routines, and kernel function.	

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	IDWC	I			DOWNWASH CHORD NO.
2	Y	R		y	Y VALUE OF DOWNWASH POINT
3	IPDWC	I			POINT/DOWNWASH CHORD
4	IDWP	I			DOWNWASH POINT NO.
5	X	R		x	DOWNWASH POINT
6	YO	R		y_0	
7	YOSQD	R		y_0^2	
8	KYO	R		$k\|y_0\|$	
9	KYOSQD	R		$(ky_0)^2$	
10	BYOSQD	R		$(\beta y_0)^2$	
11	BKYOSQD	R		$(\beta k y_0)^2$	
12	XO	R		x_0	
13	KXO	R		kx_0	
14	CMACH	R		ln(2-2M)/2	CONSTANT FOR KERNEL CALCULATION

LABELED COMMON NAME: LCSTERM	LOAD LEVEL: SECONDARY (1,5/7)
DESCRIPTION: Miscellaneous terms associated with full chord control pressure expressions.	

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	CIS	C	4	C_{IS}	COEFFICIENT/SIDE EDGE FOR INVERSE SQUARE ROOT TERMS
2	CSI	C	4	C_{S1}	COEFFICIENTS/SIDE EDGE FOR SQUARE ROOT TERM ASSOCIATION WITH FIRST SOLUTION
3	CS2	C	4	C_{S2}	SAME AS C_{S1} EXCEPT FOR SECOND SOLUTION
4	CL1	C	4	C_{L1}	COEFFICIENTS/SIDE EDGE FOR FIRST SOLUTION
5	CL2	C	4	C_{L2}	SAME AS C_{L2} EXCEPT FOR SECOND SOLUTION
6	CAT	C	4	C_{AT}	COEFFICIENTS/SIDE EDGE FOR ARC TANGENT TERM
7	GIS	R		G_{IS}	INVERSE SQUARE ROOT TERM
8	GS1	R		G_{S1}	FIRST SOLUTION SQUARE ROOT TERM
9	GS2	C		G_{S2}	SECOND SOLUTION SQUARE ROOT TERM
10	GL1	R		G_{L1}	FIRST SOLUTION LOG TERM
11	GL2	C		G_{L2}	SECOND SOLUTION LOG TERM
12	GAT	R		G_{AT}	ARC TANGENT TERM
13	CON1	R			MISCELLANEOUS CONSTANT TERMS
14	CON2	R			
15	CON3	R			
16	CCON1	C			
17	CCON2	C			

18	CCON3	C			
19	GEXP	C		$e^{ikM^2(\xi-x_s)/\beta^2}$	
20	EMYS	R		$(\eta-y_s)$	
21	BSEYS	R		$\beta SIGN(\eta-y_s)$	
22	BEMSY2	R			
23	XIXS	R		$\xi-x_s$	
24	RXIXIL	R			
25	AYS	R	4		ARRAY OF Ys FOR ALL SIDE EDGES
26	ASTANLL	R	4		ARRAY OF $\tan\Lambda_L$ FOR ALL SIDE EDGES
27	AXS	R	4		ARRAY OF $\xi_c(y_s)$ FOR ALL SIDE EDGES
28	RL	R			
29	L1	R			
30	L2	R			
31	Q1	R			
32	E2	R			
33	E3	R			

LABELED COMMON NAME: OPTIONS					LOAD LEVEL: PRIMARY (1,0)
DESCRIPTION: Miscellaneous options.					
NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	VELPFL	L			VELOCITY PROFILE OPTION .T.= PROFILES EXIST
2	DGUST	L			DESCRETE GUST OPTION
3	GPGUST	L			GRADUAL PENETRATION GUST OPTION
4	GPREF	R			GRADUAL PENETRATION GUST REFERENCE POINT
5	IIAIN	L			INDICATOR FOR DIRECT INPUT OF IIA PER MODAL INPUT ZONE
6	RESULT	L			INDICATOR FOR SOME RESULTS REQUIRED, I.E. EITHER UNSTEADY PRESSURE, SECTIONAL FORCES OR GENERALIZED FORCES.
7	SOLUTION	L			INDICATOR FOR SOLUTION REQUIRED, I.E. EITHER RESULT OR C-MATRIX, DOWNWASH MATRIX, ON PRESSURE COEFFICIENT MATRIX OUTPUT REQUESTED.

LABELED COMMON NAME: PLNGEO				LOAD LEVEL: PRIMARY (1,0)	
DESCRIPTION: Defines planform geometry.					
NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	MSID	I			MAIN SURFACE C-MATRIX I.D.
2	NLE	I			NUMBER OF LEADING EDGE DEFN. POINTS
3	XLE	R	10		LEADING EDGE DEFN. PTS. (STRAIGHT LINE SEGMENTS)
4	YLE	R	10		
5	DXLEDY	R	9		SLOPE OF LEADING EDGE SEGMENTS
6	NTE	I			NUMBER OF TRAILING EDGE DEFN. PTS.
7	XTE	R	10		
8	YTE	R	10		TRAILING EDGE DEFN. PTS. (STRAIGHT LINE SEGMENTS)
9	DXTEDY	R	9		SLOPE OF TRAILING EDGE SEGMENTS
10	NOCS	I			NUMBER OF CONTROL SURFACES
11	XHLI	R	6		CONTROL SURFACE HINGE INBOARD DEFIN. POINT
12	YHLI	R	6		
13	XHLO	R	6		CONTROL SURFACE HINGE OUTBOARD DEFN. POINT
14	YHLO	R	6		
15	DXHLDY	R	5		SLOPE OF CONTROL HINGE
16	CSID	I	6		CONTROL SURFACE C-MATRIX I.D.
17	CSTYPE	I	6		CONTROL SURFACE TYPE
18	CSRS	I	6		CONTROL SURFACE RELATED SURFACE
19	CSAO	I	6		CONTROL SURFACE AREA ORDER
20	CSRI	I	6		CONTROL SURFACE INPUT INDICATOR
21	XHLBI	R	6		HINGE INBOARD SIDE EDGE DEFN. POINT VALUE IN BAR NOTATION

22	XHLBO	R	6		HINGE OUTBOARD SIDE EDGE DEFN. POINT VALUE IN BAR NOTATION
23	XLEI	R	6		LEADING EDGE VALUE AT THE CONTROL INBOARD SIDE EDGE
24	XLEO	R	6		LEADING EDGE VALUE AT THE CONTROL OUTBOARD SIDE EDGE

LABELED COMMON NAME:	PRSPVAL	LOAD LEVEL: SECONDARY (1,1-3/5/7)
DESCRIPTION:	Used to specify (ξ,η) values to ETACVAL and other routines. Describes current chord, control surface and pressure type.	

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	ETA	R		η	SPANWISE LOCATION OR COORDINATE
2	AETA	R		$\lvert\eta\rvert$	
3	ETAB	R		$\underline{\eta}$	NON-DIMENSIONAL SPANWISE COORDINATE
4	XI	R		ξ	CHORDWISE (STREAMWISE) LOCATION OR COORDINATE
5	XIB	R		$\underline{\xi}$	NON-DIMENSIONAL CHORDWISE COORDINATE
6	DXIBE	R		$\partial\underline{\xi}/\partial\eta$	
7	ICS	I			CONTROL SURFACE NUMBER (=0 WHEN NO CONTROL SURFACE IS CONCERNED)
8	CPT	L			CONTROL PRESSURE INDICATOR, CPT=.T. IF CONTROL SURFACE PRESSURE TERM IS BEING CALCULATED.
9	XIL	R		$\xi_1(\eta)$	PLANFORM LEADING EDGE VALUE AT η
10	DXILE	R		$\partial\xi_1(\eta)/\partial\eta$	
11	XIM	R		$\xi_m(\eta)$	PLANFORM MIDCHORD VALUE AT η
12	XIC	R		$\xi_c(\eta)$	PLANFORM CONTROL NO. ICS HINGE VALUE AT η . (NOTE - THIS MAY BE A LINEAR EXTENSION.)
13	DXICE	R		$\partial\xi_c(\eta)/\partial\eta$	
14	XIT	R		$\xi_t(\eta)$	PLANFORM TRAILING EDGE VALUE AT η
15	DXITE	R		$\partial\xi_t(\eta)/\partial\eta$	
16	B	R		$b(\eta)$	PLANFORM SEMI-CHORD VAlUE AT η
17	KIND	I			KERNEL INDICATOR, USED ONLY DURING C-MATRIX CALC.
18	CQTYPE	I			CHORDWISE QUADRATURE TYPE, USED DURING C-MATRIX CALCULATION, AND SECTIONAL AND TOTAL GENERALIZED FORCES.

LABELED COMMON NAME:		PRSTERM		LOAD LEVEL: SECONDARY (1,3/5)	
DESCRIPTION:	Used by PRSPREP, SGFPREP, GFPREP, and most C-matrix calculation routines.				

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	FETA	R	72	$f(\eta)$	SPANWISE MAIN SURFACE PRESSURE TERMS
2	FPETA	R	72	$f'(\eta)$	
3	NCPTERM	I			NUMBER OF CHORDWISE PRESSURE TERMS
4	CPTERM	R	16	$g(\xi,\eta)$ or $\partial g(\xi,\eta)/\partial\eta$	CHORDWISE PRESSURE TERMS

LABELED COMMON NAME:	PRTCTL				LOAD LEVEL: PRIMARY (1,0)
DESCRIPTION:	Controls all printed output in result and solution sections.				

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	DPPRT	I			DELTA PRESSURE PRINT CONTROL
2	SGFPRT	I			SECT. GEN. FORCE PRINT CONT.
3	GFPRT	I			GEN. FORCE PRINT CONTROL
4	CMPRT	I			C-MATRIX PRINT CONTROL
5	DWMPRT	I			DOWNWASH MATRIX PRINT CONTROL
6	PCMPRT	I			PRESSURE COEFF. MATRIX PRINT CONTROL n<0 all cond. (on input) = 0 - no print n>0 - print first n cond.

LABELED COMMON NAME: QUADWTS LOAD LEVEL: PRIMARY (1,0)

DESCRIPTION: Used by GFSGRID, GFCGRID in prep. routines, and by CMCALC and chordwise quadrature routines in C-matrix calculation.

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	ALEG4	R	2		
2	HLEG4	R	2		<u>PREFIX</u>
3	ALEG8	R	4		A - ABSCISSAE
4	HLEG8	R	4		H - WEIGHTS
5	AISQR5	R	5		<u>ROOT</u> - TYPE QUADRATURE WEIGHT FUNCTION
6	HISQR5	R	5		LEG - LEGENDRE
7	AISQR10	R	10		ISQR - INVERSE SQUARE ROOT
					SQR - SQUARE ROOT
8	HISQR10	R	10		LOG - LOG
9	ALOG4	R	4		
10	HLOG4	R	4		4THR - FOURTH ROOT
11	ALOG8	R	8		<u>SUFFIX</u> _ NO. QUADRATURE POINTS
12	HLOG8	R	8		
13	ASQR5	R	5		
14	HSQR5	R	5		
15	ASQR10	R	10		
16	HSQR10	R	10		
17	A4THR5	R	5		
18	H4THR5	R	5		
19	A4THR10	R	10		
20	H4THR10	R	10		

LABELED COMMON NAME: SQUAD					LOAD LEVEL: SECONDARY (1,5)
DESCRIPTION: Used by CMCALC, SPNINT					
NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	SQTYPE	I			SPANWISE QUADRATURE TYPE
2	SQWT	R			SPANWISE QUADRATURE WEIGHT
3	ETALIL	R		η_L	η OF LOWER LIMIT FOR A SPANWISE INTEGRATION REGION
4	ETAUIL	R		η_U	η OF UPPER LIMIT FOR A SPANWISE INTEGRATION REGION
5	DELETA	R		$\eta_U-\eta_L$	SPANWISE INTEGRATION REGION WIDTH
6	ETAMID	R		$(\eta_U+\eta_L)/2$	REGION MIDPOINT
7	ALNDELY	R		$\ln[(\eta_U-\eta_L)/S]$	
8	ETAL	R		η_1	η VALUE OF LOG SINGULARITY LOCATION DURING SPANWISE INTEGRATION. IT IS EITHER DOWNWASH CHORD, OR A CONTROL SIDE EDGE.

LABELED COMMON NAME:	TIMES	LOAD LEVEL: PRIMARY (1,0)
DESCRIPTION:	Accumulated Cp times and number of entries for various secondary level overlays.	

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	TINP	R			ACCUMULATED CP TIME IN INPREP
2	TMIP	R			ACCUMULATED CP TIME IN MIPREP
3	TRESP	R			ACCUMULATED CP TIME IN RESPREP
4	NTRWC	I			NO. ENTRIES INTO RDWRTC
5	TRWC	R			ACCUMULATED CP TIME IN RDWRTC
6	NTCMC	I	5		1) ASSOCIATED WITH MAIN SURFACE, k = 0 2) ASSOCIATED WITH MAIN SURFACE, k > 0 3) ASSOCIATED WITH CONTROL SURFACE, k = 0 4) ASSOCIATED WITH CONTROL SURFACE, k > 0 5) TOTAL 1) - 4)
7	TCMC	R	5		ACCUMULATED CP TIME IN CMCALC (SAME AS NTCMC)
8	NTSOLN	I			NO. ENTRIES INTO SOLN
9	TSOLN	R			ACCUMULATED CP TIME IN SOLN
10	NTRES	I			NO. ENTRIES INTO RESULTS
11	TRES	R			ACCUMULATED CP TIME IN RESULTS

4.3 PROGRAM AND SUBROUTINE DESCRIPTION

Short abstracts for the various programs and subroutines in RHOIV are included in this section. A full description of each routine may be found in the program listing.

Routines are ordered alphabetically; their positional relation is shown in figure 7, page 132.

PROGRAM - SUBROUTINE STRUCTURE

BLOCK	LENGTH	BLOCK	LENGTH	BLOCK	LENGTH
(00,00)	1	(01,01)	1	(01,04)	1
ZRHOIV	12720	INPREP	2336	RDWRTC	1526
		ERRPRT	1401		
		PLNINCK	320		
(01,00)	1	CSINCK	607	(01,05)	1
/BASIC/	24	VPINCK	167	/CMVAL/	6642
/CMLIB/	14	VPINCK2	214	/KRNVAR/	16
/COND/	52	SCAMP4	250	/SQUAD/	10
/COUNT/	20	COMCU	2512	CMCALC	620
/DWPTS/	124	CUBIC2	120	SGRID	414
/ENDIT/	3	DERIV1	107	ORDER	50
/FILES/	16	DERIV2	103	GXYYCAL	432
/PLNGEO/	222	NAMBLD	45	SPININT	300
/PRTCTL/	6	DWINCK	573	CHDINT	552
/OPTIONS/	7	PRSINCK	503	CGRID	1457
RHOIV	212	SGFINCK	256	CQLEG4	75
IIARDR	47	MIINCK	1704	CQLEG8	75
/QUADWTS/	176			CQISR5	64
BLKDATA	3	(01,02)	1	CQISR10	64
/CSVAL/	26	MIPREP	273	CQLOG4	141
/PRSPVAL/	22	IIACAL	213	CQLOG8	141
ETACVAL	146	PLATEI	434	CQSQR5	66
AZONE	151	PLATET	155	CQSR10	66
AINTL	166	PLATEA	205	CQ4R5	66
PLATEO	544	CRCOEFF	672	CQ4R10	66
ZEROCOL	65	CPRDR	103	CPFCTXI	61
/PRSTERM/	43	VPCALC	144	DTETERM	1271
SPFCTE	174	CTHETA	74	DLETERM	1110
CMSTERM	114			DLFCT	135
/CQUAD/	4			/KRNTERM/	17
/CSTERM/	102	(01,03)	1	KRNFCT	375
TETERM	1206	RESPREP	722	BESK1	142
E2	30	CCRRDR	54	BI1ML1	167
DE2	101	DWPREP	714	APROX	232
/LCSTERM/	140	VPRDR	103	SERIES1	115
CSINIT	422	VPCALC	144	SERIES2	170
LETERM	400	PRSPREP	440	SERIES3	142
LFCT	52	SGFPREP	677	SICI	216
MATIO	340	GFPREP	731		
		GFSGRID	307		
		GFCGRID	720		
		(01,06)	1	(01,07)	1
		SOLN	214	RESULTS	411
		PCMDWN	1417	FORMDP	1250
		SOLVE	531	RTHETA	102
		PCMSPT	323	FORMQS	772
				FORMQ	725

Figure 7

(1) SUBROUTINE AINTL (X,Y,NPTS, Z,NROWZ,NCOL1,NCOLS, SA, INDD, DZ1, DZ2)

Interpolation cover routine for generation of displacements and slopes at unsteady aerodynamics control points - specified in the local axis system.

(2) SUBROUTINE APROX

Routine APROX performs the integration of TAU*EXP(I*KYO*TAU)/SQRT(1.+TAU**2). In TAU from -∞ to H. The function TAU/SQRT(1.+TAU**2) is approximated by a series of exponential, NASA technical report R-48, page 8,
TAU/SQRT(1.+TAU**2) = 1. +C1*EXP(E1*TAU) + C2*EXP(E2*TAU) + C3*EXP(E3*TAU)*SIN(PI*TAU)

(3) SUBROUTINE AZONE (Y, X, NPTS, IND, ZONE)

Assign a modal input zone number to points on chord Y.

(4) FUNCTION BESK1 (X)

BESK1 = K1(X), modified Bessel function of the second kind of order 1. K1(X) is calculated with two polynomial expansions, one for X.LT.2, and one for X.GE.2. Equations taken from Handbook of Mathematical Functions, National Bureau of Standards, 1967. Bessel Functions of Integer Order, 9.8 Polynomial Approximation, p. 378, 9.6.11 Ascending Series, p. 375.

(5) FUNCTION BI1ML1(X)

BI1ML1 = (I1(X) - L1(X)) where I1 = Modified Bessel function of the first kind of order 1, L1 = Struve function.

Series expansion for I1-L1 is used for X.LE. 12.8, an asymptotic expansion is used for X.GT. 12.8.

Equations taken from Handbook of Mathematical Functions, National Bureau of Standards, 1967.

Struve Functions and Related Functions, 12.2.6 Asymptotic Expansion p. 498, 12.2.1 Power Series p. 498.

Bessel Functions of Integer Order, 9.6.10 Ascending Series, P. 378.

(6) BLKDATA

Defines all quadrature abscissae and weights.

(7) SUBROUTINE CCRRDR (CCR, NPMOS)

Read cubic coefficients of control rotation.

(8) SUBROUTINE CGRID (NIR, XIQ, IRTYPE)

Routine CGRID defines the chordwise integration schemes used to integrate chordwise pressure terms times one of the kernel expressions on a specified chord.

(9) SUBROUTINE CHDINT

Perform the chordwise integration of chordwise pressure terms times kernel function.

(10) OVERLAY (RHOIV, 1,5) PROGRAM CMCALC

Calculate a C-matrix associated with main surface or control surface pressure terms for a set of downwash points at a particular k-value Mach number condition.

(11) SUBROUTINE CMSTERM

Calculate NCPTERM chordwise pressure terms associated with the assumed main surface pressure terms.

(12) SUBROUTINE CPFCTXI

Calculate NCPTERM chordwise pressure terms

KIND = GXYY, calculate G(XI,Y), DG(XI,Y)/DETA

= non-sing or singular calculate G(XI,ETA)

CPT = .F.-main surface terms, .T.-control surface terms

LECS = .FALSE.-calculate only T.E. control surface terms
.TRUE.-calculate both T.E. and L.E. control surface terms

(13) SUBROUTINE CQISR5

Perform A 5 pt. inverse square root quadrature on chordwise pressure term times kernel function for XI over XILIL to XIUIL where the square root singularity is at XILIL.

(14) SUBROUTINE CQISR10

Perform a 10 pt. inverse square root quadrature on chordwise pressure term times kernel function for XI over XILIL to XIUIL where the square root singularity is at XILIL.

(15) SUBROUTINE CQLEG4

Perform a 4 pt. Gauss-Legendre quadrature on chordwise pressure term times kernel function for XI over XILIL to XIUIL.

(16) SUBROUTINE CQLEG8

Perform a 8 pt. Gauss-Legendre quadrature on chordwise pressure term times kernel function for XI over XILIL to XIUIL.

(17) SUBROUTINE CQLOG4

Perform a combination 4 pt. log and 4 pt. Legendre quadrature on chordwise pressure term times kernel function for XI over XILIL to XIUIL where the log singularity is at XILIL.

(18) SUBROUTINE CQLOG8

Perform a combination 8 pt. log and 8 pt. Legendre quadrature on chordwise pressure term times kernel function for XI over XILIL to XIUIL where the log singularity is at XILIL.

(19) SUBROUTINE CQSQR5

Perform a 5 pt. square root quadrature on chordwise pressure term times kernel function for XI over XILIL to XIUIL where the square root slope singularity is at XILIL.

NOTE: Abscissae and weights developed from Gauss-Mehler form, refer to Kopal, Numerical Analysis, pp. 381-2, using BCS program MEHQAH (Redman 1973) with ALPHA=0, BETA=.5.

(20) SUBROUTINE CQSQR10

Perform a 10 pt. square root quadrature on chordwise pressure term times kernel function for XI over XILIL to XIUIL where the square root slope singularity is at XILIL.

NOTE: Abscissae and weights developed from Gauss-Mehler form, refer to Kopal, Numerical Analysis, pp. 381-2, using BCS program MEHQAH (Redman 1973) with ALPHA=0, BETA=.5.

(21) SUBROUTINE CQ4R5

Perform a 5 pt. fourth root quadrature on chordwise pressure term times kernel function for XI over XILIL to XIUIL where the 3/4 root slope singularity is at XILIL.

NOTE: Abscissae and weights developed from Gauss-Mehler form, refer to Kopal, Numerical Analysis, pp. 381-2, using BCS program MEHQAH (Redman 1973) with ALPHA=0, BETA=.25.

(22) SUBROUTINE CQ4R10

Perform a 10 pt. fourth root quadrature on chordwise pressure term times kernel function for XI over XILIL to XIUIL where the 3/4 root slope singularity is at XILIL.

NOTE: Abscissae and weights developed from Gauss-Mehler form, refer to Kopal, Numerical Analysis, pp. 381-2, using BCS program MEHQAH (Redman 1973) with ALPHA=0, BETA=.25.

```
(23) SUBROUTINE CRCOEFF (NZONES, NDMDS, NPMDS, DELDZDX, CCR,
     1                   Z, IIA, IIAP)
```

Calculate (or read) the cubic coefficients of control surface rotation for subsequent use in the preparation routines. The coefficients are defined such that

```
THETA(ETA) = C0 + C1*EBCS + C2*EBCS**2 + C3*EBCS**3
           = change in streamwise modal slope,
             DELTA DZ/DX, at the hinge.
      EBCS = fraction (0.,1.) of control span
             (0. inboard, 1.0 outboard)
```

(24) SUBROUTINE CTHETA (DELDZDX, NDMDS)

Given four equally spaced points on a control hinge, and DELTA DZ/DX at these points, determine the coefficients of the cubic which will define DELTA DZ/DX, THETA, on the hinge.

(25) SUBROUTINE CSINCK (CSAREA, PLNERR, CSERR)

Read control surface input. Check legality. Assign control type, and determine related surfaces.

(26) SUBROUTINE CSINIT

Initialize variables for a control surface and generate coefficients of control pressure expression.

(27) SUBROUTINE DLETERM (DGXIETA)

Calculate the derivative of the pressure term G(XI,ETA) with respect to ETA for a leading edge control surface.

(28) SUBROUTINE DTETERM (DGR, DGI)

Calculate the derivative of the pressure term for a trailing edge control, DG(XI,ETA)/DETA = (DGR,DGI)

(29) SUBROUTINE DWINCK (PLNERR, DWERR)

Read (or use default definition for) downwash chords and points, convert from bar notation if required, and check legality.

```
(30) SUBROUTINE DWPREP (NDWC, NPDWC, NDWP, NDWP2, NOCS, NZONES,NDMDS,
     1                  NPMDS, YDWC, XDWP, X,Y, ZONE, IPOS, NPZONE,
                        Z,ZT, DZDX,DZDXT, W, WRI, IIA, IIAP, CCR)
```

Form the basic downwash matrix, [W] = [DZ/DX + I*Z], and write to RESFILE. The real portion of W is modified by any user supplied velocity profile, and a gust mode of the desired form is appended if requested. Any existing cubic coefficients of control rotation are copied from memory to RESFILE.

```
(31) SUBROUTINE ERRPRT (IERRNO, ERRFLG, I1, I2)
```

Set error flag and print appropriate error message.

```
(32) SUBROUTINE ETACVAL
```

Given a spanwise station, ETA, determine the leading edge, trailing edge, and hinge line (if applicable) intersects, and calculate semi-chord and mid-chord values.

```
(33) SUBROUTINE FORMDP (NPRC, NPPRC, NPPT, NPTRM, NOCS, NPMDS,
     1                  YPRC, XPPT, XBAR, PRESS, MSPTRM, GXIETA,
     2                  CMSPT, FETA, AMPPHAS)
```

Calculate unsteady delta pressure at an indicated set of points (output points) for a k-value/Mach no. condition.

```
     DELP(X,Y;J) =  SUM[ MSPTRM(X,Y;I)*CMSPT(I,J) , I=1,NPTRM ] +
                    SUM[ FETA(Y,J)*GXIETA(X,Y;N) , N=1,NOCS ]
```

```
(34) SUBROUTINE FORMQ (NDMDS, NPMDS, NPTRM, NOCS, MICHD, MPICHD,
     1                 Q, QMSPT, CMSPT, YICHD, GXIETA, XIPT, QTYPE,
     2                 FETA, WZ)
```

Calculate the generalized unsteady aerodynamic coefficient matrix (generalized forces) for a k-value/Mach number condition.

```
     Q(I,J) = INTEGRAL [ Z(XI,ETA;I)*DELP(XI,ETA;J)*D[XI]*D[ETA] ]
                   XI = XIL(ETA) , XIT(ETA)
                  ETA = O, S
```

```
(35) SUBROUTINE FORMQS (NSGFC, NDMDS, NPMDS, NPTRM, NOCS, MPSGFC,
     1                  Y, QS, QSMSPT, CMSPT, GXIETA, XIPT, QTYPE,
     2                  FETA, WZ)
```

Calculate the sectional generalized unsteady aerodynamic coefficient matrices (sectional forces) at an indicated set of chords for a k-value/Mach no. condition.

```
QS(Y;I,J)  =     INTEGRAL[  Z(XI,Y;I)*(DELP(XI,Y;J)*D[XI] ]
                        XI = XIL(Y), XIT(Y)
```

(36) SUBROUTINE GFCGRID (NIPTS, NPZONE, XIPT, CQWT, QTYPE)

Determine the quadrature points and associated weights to be used in integrating delta pressure times displacements along a chord for sectional or total generalized forces.

(37) SUBROUTINE GFSGRID (NICHD, YICHD, SQWT)

Determine the quadrature chords and associated weights to be used in the spanwise integration of delta pressure times displacements for total generalized forces.

```
(38) SUBROUTINE GFPREP (MICHD, MPCHD, NZONES, NDMDS, NPMDS, NSPT,
     1                   NCPT, NPTRM, YICHD, SQWT, NIPTSZ, XIPT,
     2                   YIPT, CQWT, QTYPE, QMSPT, Z, WZ, G FETA, IIA,
     3                   IIAP, CCR, MICGF, MIPGF)
```

Prepare information, independent of k-value and Mach no., which will be used for calculation of generalized unsteady aerodynamic coefficients (generalized forces). The information is written to RESFILE.

(39) SUBROUTINE GXYYCAL

Calculate G(X,Y,Y) and GP(X,Y,Y) for all points on a downwash chord and initialize the associated C-matrix rows.

(4) SUBROUTINE IIACAL (NZONES, MIPTS, MEQNS, NDMDS, X, Y, Z, IIA)

Generate the interpolation information array for each modal input zone and save on MISFILE.

(41) SUBROUTINE IIARDR (IIAP, IIA, LIIA)

Read the interpolation information arrays.

(42) OVERLAY (RHOIV, 1, 1) PROGRAM INPREP

Process all user input.

(43) SUBROUTINE KRNFCT

Calculate the desired kernel function as specified by KIND, e.g. GXYY, NON-SING, SINGULAR.

(44) SUBROUTINE LETERM (GXIETA)

Calculate the pressure term G(XI,ETA) for a leading edge control surface.

(45) SUBROUTINE MATIO (LFN, MATRIX, MROWD, MROW, MCOL, LID, ID, IRR)

Read/write a two record set consisting of an ID record describing a matrix or array, and the matrix record.

(46) SUBROUTINE MIINCK (NROWZ, X, Y, IPOS, ZONE, Z, IIA, NIPTS, 1 PLNERR, MIERR)

Read modal input (from INPUT or MIFILE), check legality, and write by input zone to INSFILE. Alternatively, read interpolation information arrays by input zone and write directly to MISFILE. The information is used in MIPREP and RESPREP.

(47) OVERLAY (RHOIV, 1, 2) PROGRAM MIPREP

Allocate working area for the modal preparation routines which will generate information on MISFILE to be used in RESPREP.

(48) SUBROUTINE NAMBLD (NMFILE)

Convert NMFILE = NM to NMFILE = TAPENM

(49) SUBROUTINE PCMDWM (NDWP, NPTRM, NOCS, NPMDS, C, CS, AS, W, WRI)

Print the C-matrices associated with regular (main surface) assumed pressure terms and any control surface pressure term. Print the kinematic downwash matrix, and the residual downwash

matrix (the kinematic downwash matrix with any control surface singularities removed).

(50) SUBROUTINE PLATEO (XO, YO, NOPTS, ZO, NROWZ, NCOL1, NCOLS, SA,
     1   INDD, DZ1, DZ2)

Given the spline coefficients for a set of functions as determined in routine PLATEI, and the associated input points, calculate the values of the functions (and optionally the derivatives) at a set of output points.

(51) SUBROUTINE PCMSPT (NDWP, NPMDS, CMSPT)

Print the coefficients of the regular (main surface) assumed pressure terms.

(52) SUBROUTINE PLATEA (X, Y, INDS, SK, N, M, A, IRR)

Form the coefficient matrix for system of equation, SK = smoothing constant (ratio of plate stiffness to input pcint spring stiffness).

```
                        * 1 X(1) Y(1)        Where A(I,J = R**2 LN(R**2, I≠J
                        * -   -    -
     A(I,J)             * -   -    -                      = 0, I=J      INDS = 0
                        * -   -    -
                        * 1 X(N) Y(N)                     = SK(1), I=J  INDS=1
                        *
*****************************                             = SK(I), I=J  INDS=2
                        *
  1  ---   1            * 0   0    0             R= (X(I)-X(J)**2
X(1) --- X(N)           * 0   0    0                   +(Y(I)-Y(J))**2
Y(1) --- Y(N)           * 0   0    0             N=No. pts., M=N+3= No. eqs.
```

(53) SUBROUTINE PLATEI (XI, YI, MIPTS, ZI, NROWZ, MCOL1, MCOLN,
     1   MCOLS, SA, INDS, SK)

Perform a bivariate interpolation using as the interpolating function the small deflection equation of an infinite pinned plate.

Reference: Robert L. Harder, Robert N. Desmarais; Interpolation Using Surface Splines, J. Aircraft, Vol 9 No. 2, Feb. 1972

(54) SUBROUTINE PLATET (XU, YV, NIND, XBAR, YBAR, COST, SINT,
RGU, RGV)

Perform a transformation of coordinates from (X,Y) to (U,V) if NIND>0, or from (U,V) to (X,Y) if NIND<0.

```
*U*   *1/RGU    0    * * COST SINT* *X-XBAR*
* * =*               * *          * *      *
*V*   *   0   1/RGV  * *-SINT COST* *Y-YBAR*
```

Where COST = COS(THETA), SINT = SIN(THETA), THETA is that angle such that PUV = SUM[U(I)*V(I)]N = 0, RGU,RGV = radii of gyration in (U,V), XBAR,YBAR = C.G. location in (X,Y) - note UBAR,VBAR = 0,0

(55) SUBROUTINE PLNINCK (PLNERR)

Read the leading edge and trailing edge definition, and check for compatibility.

(56) SUBROUTINE PRSINCK (YPRC, XPPT, PLNERR, PRSERR)

Read (or use default) pressure output chord and point values, check for legality and save on INSFILE.

(57) SUBROUTINE PRSPREP (NPRC, NPPRC, NPPT, NSPT, NCPT, NPTRM,
1 MOCS, NPMDS, YPRC, XPRT, MSPTRM, FETA, CCR)

Prepare information, independent of k-value and Mach no., which will be used during calculation of unsteady delta pressures. The information is written to RESFILE.

(58) OVERLAY (RHOIV, 1,4) PROGRAM RDWRTC

Perform all read/write activities associated with the CMFILE library of C-matrices and its index.

(59) OVERLAY (RHOIV, 1,3) PROGRAM RESPREP

Allocate working area for the various preparation routines which will in turn generate information which is placed on RESFILE for subsequent use in solving for the coefficients of the assumed main surface pressure terms, and in calculation unsteady pressures, sectional forces, or total generalzied force results.

(60) OVERLAY (RHOIV, 1,7) PROGRAM RESULTS

Allocate working area for the result routines which will in turn generate the requested results for printed or user file output.

(61) OVERLAY (RHOIV, 1,0) PROGRAM RHOIV

Calculate the unsteady aerodynamic loadings on a lifting surface with leading and/or trailing edge sealed gap controls undergoing harmonic motions in subsonic compressible flow.

(62) SUBROUTINE RTHETA (PRESS, AMPPHAS, NPPT, NMDS)

Convert pressure at a point from (X+IY) form to (R, THETA).

(63) SUBROUTINE SCAMP4 (X,Y,N,NDA,NDB,DA,DB,C,S,M)

Given a set of N points whose absicissae form a strictly monotone sequence, and given a first or second derivative at X(1) and a first or second derivative at X(N), to find the smoothest possible curve passing rigorously through the given points, satisfying the specified boundary conditions, and possessing continuous first and second derivatives. The criterion of smoothness is the minimization of the integral of the square of the second derivative, and the curve found is accordingly a chain of cubics, i.e., a separate cubic on each interval X(I), X(I+1).

(64) SUBROUTINE SERIES1

Routine SERIES1 performs the integration of

EXP (I*LAMBDA)/(LAMBDA**2 + (K*YO)**2)**1.5

In LAMBDA from - infinity to - K*F, where K*F = 2*PI. A change of variables is made, and a series expansion of the denominator is written. Using partial integration a recursion formula is developed which converges to within required accuracy in ten iterations or less.

(65) SUBROUTINE SERIES2

Routine SERIES2 performs the integration of

(EXP(I*LAMBDA) -1 -I*LAMBDA +.5*LAMBDA**2)/(LAMBDA**2+(K*Y0)**2)$^{3/2}$

In LAMBDA from -K*F to K*H, when K*H > -K*F where K*F = 2*PI. A series expansion of the exponent is written. The first three terms of the series cancel with the remaining three terms in the numerator. Performing partial integration twice, a recursion formula for the integral of the remaining terms is developed which converges to within the required accuracy within 50 iterations or less (K*H≤15).

(66) SUBROUTINE SERIES3

Routine SERIES3 performs the integration of

EXP (I*LAMBDA)/(LAMBDA**2 + (K*Y0)**2**1.5

In LAMBDA from - infinity to K*H when K*H ≤ -K*F, K*F = 2*PI. SERIES3 is the same as SERIES1 except the sine and cosine integrals of the upper integration limit cannot be precalculated.

(67) SUBROUTINE SGFINCK (YSGFC, PLNERR, SGFERR)

Read (or use default values for) sectional force output chords for legality and save on INSFILE.

(68) SUBROUTINE SGFPREP (NSGFC, MPCHD, NZONES, NDMDS, NPMDS, NSPT,
1 NCPT, NPTRM, YSGFC, NIPTSZ, XIPT, YIPT,
2 CQWT, QTYPE, QSMSPT, Z, WZ, FETA, IIA, IIAP,
3 CCR, MIPSGF)

Prepare information, independent of k-value and Mach no., which will be used for calculation of sectional generalized unsteady aerodynamic coefficients (sectional forces). The information is written to RESFILE.

(69) SUBROUTINE SGRID (NIR, ETAQ, IRTYPE)

Routine SGRID defines the spanwise integration scheme used to integrate the spanwise integrand of the downwash integral equation for all downwash points on a specified downwash chord.

(70) SUBROUTINE SICI

Computes the sine and cosine integral.

(71) OVERLAY (RHOIV, 1,6) PROGRAM SOLN

Allocate working area for the solution routine and intermediate output routines.

(72) SUBROUTINE SOLVE (NDWP, NPTRM, NOCS, NPMDS, MMDS,
     1   C, SCR, IPR, CS, AS, W, WRI)

Solve the complex linear system of equations for the coefficients of the assumed regular (main surface) pressure terms and save on COFFILE.

(73) SUBROUTINE SPFCTE

Calculate NSPT spanwise pressure terms

KIND = GXYY, calculate F(ETAB) and FP(ETAB) = DF(ETAB)/DETA

= NON-SING, or SINGULAR, calculate F(ETAB)

CPT = .F. - main surface terms, ≠ .T. - control surface terms

(74) SUBROUTINE SPNINT

Evaluate the spanwise integrand at ETA, and increment the C-matrix terms by the weighted results.

(75) SUBROUTINE TETERM (GR, GI)

Calculate the pressure term G(XI,ETA) = CMPLX(GR,GI) for a trailing edge control.

(76) SUBROUTINE VPINCK (VPERR)

Read velocity profiles, check for legality, form a cubic spline for each profile, and save on INSFILE.

(77) SUBROUTINE ZEROCOL (M, NF, NL, Z, NROWZ, INDD, DZ1, DZ2)

Initialize columns NF-NL to zero for M rows.

(78) OVERLAY (RHOIV, 0,0) PROGRAM ZRHOIV

Call overlay RHOIV (1,0)

Page Intentionally Left Blank

APPENDIX A - NUMERICAL INTEGRATION TECHNIQUES

The basic work performed by the RHOIV program is numerical integration. In particular this includes the surface integration of the pressure kernel expression of the downwash integral equation (eqn 2.3-1), or the integration along a chord of unsteady pressure times modal deflection for sectional generalized forces (eqn 2.8-4), or the surface integration of unsteady pressure times modal deflection for total generalized forces (eqn 2.8-9). The numerical integration is accomplished using Gaussian quadrature of the general form,

$$\int_{\alpha}^{\beta} w(t)f(t)dt = \sum_{1}^{n} H_i f(a_i) \qquad \text{(A.1-1)}$$

where $f(t)$ = the function to be integrated with the associated term,
$w(t)$ = a known positive function of t, the weight function.
and H_i = the quadrature weights corresponding to,
a_i = the quadrature abscissae.

The abscissae are roots of an nth degree polynomial which is orthogonal with respect to the weight function $w(t)$ on (α,β). A discussion of the existence and determination of the set of a_i and corresponding H_i for which eqn A.1-1 will be exact, provided $f(t)$ is of degree $\leq 2n-1$, is given in reference 3, Chapter VII. The properties of a_i and H_i include,

a_i real and distinct

$H_i > 0,\ i=1,\ldots,n$

$\alpha < a_i < \beta,\ i=1,\ldots,n$

$$\sum_{1}^{n} H_i = \int_{\alpha}^{\beta} w(t)dt$$

The usual approach is to determine a_i and H_i for a known interval, e.g. (0,1), and perform a linear transformation of variables from, for example, x on (a,b) to t on (0,1).

The weight functions used within RHOIV are:

$w(t) = 1$ (for which the abscissae are roots of an nth degree Legendre polynomial on (α,β) --

referred to as Legendre quadrature)

$w(t) = \sqrt{t-\alpha}$ (referred to as square root quadrature)

$w(t) = 1/\sqrt{t-\alpha}$ (referred to as inverse square quadrature)

$w(t) = \ln(t-\alpha)$ (refered to as log quadrature)

For integration performed in evaluation of the downwash integral equation, the integrand and its first derivative are well behaved over the majority of the surface, thus Gauss-Legendre quadrature is most prevalently used. However, the first chordwise pressure term, $\cot(\theta/2)$, for a main surface analysis has a square root singularity at the planform leading edge, and the remaining chordwise pressure terms for both main surface and control surface analyses have a square root (or similar order) discontinuity in the first derivative at the planform leading and trailing edges. Additionally the spanwise terms for both analyses have a square root (or similar order) discontinuity in the first derivative at the planform tips. The kernel expression contains a logarithmic singularity at a downwash chord (y) in spanwise integration, and a logarithmic singularity exists in the chordwise pressure form at a physical control surface hinge line. Thus Log quadrature is used in regions which include the above singularities. Note that because of the predetermination of the weights and abscissae on an interval (0,1), the integration of a logarithmic singularity involves both Log and Legendre quadratures.

For integration performed in calculation of sectional and total generalized forces the kernel function singularities are not involved, however the singularities associated with the pressure terms remain and are handled in the same manner.

The form of the quadratures used is,

Gauss-Legendre Quadrature

$$\int_a^b f(x)dx = (b-a)\int_0^1 f(t)dt = (b-a)\sum_1^n H_i f(x_i) \qquad \text{(A.1-2)}$$

where n = 4 or 8

H_i = the n point Gauss-Legendre quadrature weights

x_i = $(b-a)t_i + a$, t_i = the n point Gauss-Legendre quadrature abscissae (note that H_i and x_i are symmetric about $(b+a)/2$

Square Root Quadrature

$$\int_a^b \sqrt{x-a}\, f(x)dx = (b-a)\int_0^1 \sqrt{(b-a)t}\, f(t)dt = (\sqrt{b-a})^3 \int_0^1 \sqrt{t}\, f(t)dt \qquad \text{(A.1-3)}$$

$$= (\sqrt{b-a})^3 \sum_1^n Hs_i f(x_i)$$

where n = 5 or 10

Hs_i = the n point Square Root Quadrature weights

X_i = $(b-a)t_i + a$, t_i = the n point Square Root Quadrature abscissae

$f(x) = g(x)/\sqrt{x-a}$, where $g(x)$ has the characteristic of $\sqrt{x-a}$

Inverse Square Root Quadrature

$$\int_a^b f(x)/\sqrt{x-a}\, dx = (b-a)\int_0^1 f(t)/\sqrt{(b-a)t}\, dt = \sqrt{b-a}\int_0^1 f(t)/\sqrt{t}\, dt \qquad \text{(A.1-4)}$$

$$= \sqrt{b-a} \sum_1^n His_i f(x_i)$$

where n = 5 or 10

His_i = the n point Inverse Square Root Quadrature weights

$x_i = (b-a)t_i + a$, t_i = the n point Inverse Square Root Quadrature abscissae

$f(x) = g(x)\sqrt{x-a}$, where g(x) has a square root singularity of the form $1/\sqrt{x-a}$

Log (Plus Legendre) Quadrature

$$\int_a^b \ln|x-a|\ f(x)dx = (b-a)\int_0^1 \ln|(b-a)t|\ f(t)dt \tag{A.1-5}$$

$$= (b-a)\ln|b-a|\int_0^1 f(t)dt + (b-a)\int_0^1 \ln|t|\ f(t)dt$$

$$= (b-a)\ln|b-a|\sum_1^n H_i f(x_i) - (b-a)\sum_1^n Hl_j f(x_j)$$

where n = 4 or 8

H_i and x_i are as defined in C.1-2

Hl_j = the n point Log quadrature weights associated with

$w(t)=\ln(1/t)$.

$x_j = (b-a)t_j + a$, t_j = the n point Log quadrature abscissae

$f(x) = g(x)/\ln|x-a|$, where g(x) has a logarithmic singularity of the form $\ln|x-a|$

APPENDIX B - MODAL INTERPOLATION

If input points and modal displacements are provided by the user to RHOIV, the surface spline method of Harder and Desmarais, Reference 5, is used to allow interpolation for displacements and streamwise slopes at downwash points, and displacements at quadrature points used for sectional and total generalized force integration.

If control surfaces exist, the lifting surface planform is divided into modal input zones, as illustrated in figure 8, page 155, each of which must have a sufficient number of input points to define the motion within that region.

The user has two options when describing lifting surfaces with controls:

(1) Provide a descrete set of input points with associated modal displacements for each modal input zone,

(2) Provide a total set of points with associated modal displacements which includes points in all zones.

In the first case, the input points for an input zone need not lie within the boundaries of that zone. In the second case RHOIV will assign an input zone to each point based on the boundaries shown in figure 8. In either case a minimum of three (3) input points must be associated with each input zone; the interpolation procedure described below, is applied <u>per input zone</u>.

The control surface pressure modes are a function of control rotation, $\theta(\eta)$, or the change in streamwise slope across a control hinge. Unless the user specifically provides this information, RHOIV will determine θ by calculating the slope at the hinge using the interpolating functions for the two modal input zones on either side of the hinge.

With a reasonably even distribution of points in a zone, the surface spline approach provides good results for displacements, and reasonable results for slopes at points <u>interior</u> to the input point set. At the extremeties of input point regions a fair amount of curvature may exist, introducing sometimes large "errors" in the slopes. This is particularly significant since the leading edge and any control hinge tend to lie at the extremeties of input point sets and thus errors in boundary condition at the leading edge, and control rotation θ, may be introduced.

For any particular planform configuration, the user should initially examine the kinematic downwash and control rotations to assure the sufficiency of his input point distribution. If the user is unable to cause reasonable control rotation values to be calculated by moving input points or including more input points the option to input control rotation information should be used.

<u>IF REASONABLE SLOPES AT DOWNWASH POINTS, AND CONTROL ROTATION VALUES ARE NOT CALCULATED THE PROGRAM RESULTS WILL HAVE NO SIGNIFICANCE</u>

If the surface spline approach is used, the modes are approximated by, (Reference 5),

$$Z(\xi,\eta) = \sum_{1}^{N} a_i R_i^2 \cdot \ln(R_i^2) + a_{N+1} + a_{N+2}\xi + a_{N+3}\eta$$

$$R_i = (\xi - x_i)^2 + (\eta - y_i)^2$$

$$(x_i, y_i) = N \text{ input points}$$

under the constraints

$$Z(x_i, y_i) = Z_I(x_i, y_i), \quad i = 1, N$$

where $Z_I(x_i,y_i)$ = input values at (x_i,y_i), and

$$\sum_{1}^{N} a_i = 0, \quad \sum_{1}^{N} a_i x_i = 0, \quad \sum_{1}^{N} a_i y_i = 0$$

which expressed in matrix form for n input modes,

$$\left[\begin{array}{c|ccc} & 1 & x_1 & y_1 \\ A_{ij} & \vdots & \vdots & \vdots \\ & 1 & x_N & y_N \\ \hline 1 \dots 1 & & & \\ x_1 \dots x_N & & 0 & \\ y_1 \dots y_N & & & \end{array}\right] [\{a\}_1 \dots \{a\}_n] = [\{Z_I(x_i,y_i)\}_1 \dots \{Z_I(x_i,y_i)\}_n]$$

$$A_{ij} = \begin{cases} 0, & i=j \\ R_{ij}^2 \cdot \ln(R_{ij}^2), & i \neq j \end{cases}$$

$$R_{ij}^2 = (x_i - x_j)^2 + (y_i - y_j)^2$$

is a linear system of equations which may be solved for the interpolating function coefficients.

Then for any output point, (ξ,η),

$$\lfloor Z(\xi,\eta)_1,\ldots,Z(\xi,\eta)_n \rfloor = [a_{ij}] \begin{Bmatrix} A_i \\ 1 \\ \xi \\ \eta \end{Bmatrix} \qquad A_i = R_i^2 \cdot \ln(R_i^2),\ i = 1,N$$

$$\left\lfloor \frac{\partial Z(\xi,\eta)_1}{\partial x},\ldots,\frac{\partial Z(\xi,\eta)_n}{\partial x} \right\rfloor = [a_{ij}] \begin{Bmatrix} B_i \\ 0 \\ 1 \\ 0 \end{Bmatrix} \qquad B_i = 2(\xi - x_i)[\ln(R_i^2)+1],$$

$$i=1,N$$

where $Z(\xi,\eta)$ has the properties

$Z(x_i,y_i) = Z_I(x_i,y_i),\ i = 1,N$

$\frac{\partial^2 Z(\xi,\eta)}{\partial x^2}, \frac{\partial^2 Z(\xi,\eta)}{\partial x \partial y}, \frac{\partial^2 Z(\xi,\eta)}{\partial y^2} \rightarrow 0$ as the distance to the input point $\rightarrow \infty$

$Z(\xi,\eta)$ is analytic everywhere except at (x_i,y_i)

$\frac{\partial Z(\xi,\eta)}{\partial x}, \frac{\partial Z(\xi,\eta)}{\partial y}$ exist at (x_i,y_i)

If N = 3 and the points are non colinear, a simple plane is defined for $Z(\xi,\eta)$.

Note that a simple bending mode (1st, 2nd, etc.) is not adequately defined by input points lying in two lines because of the tendency of the interpolation function used to force curvature to zero in both coordinates.

The change in slope at a control hinge for a spanwise station y is determined by calculating the slope at the hinge using first the interpolation information for the surface to which the control is related and then using the interpolation information for control surface itself. Rather than calculate the slope analytically, which, in the case of a surface spline representation, may introduce control rotations where none exist, a numerical procedure is used.

At a spanwise station y, three equally spaced points (including the hinge) are selected over a sufficiently small region, δ, e.g. $2\delta = (x_3-x_1) = .005S$, so that it can be assumed that no curvature of the physical planform exists. If the displacements at the points are determined, a quadratic in $(x-x_1)$ may be written,

$$Z(x) + A_1+B(x-x_1) + C(x-x_1)^2, \text{ or}$$

$$\partial Z(x)/\partial x = B + 2C(x-x_1)^2$$

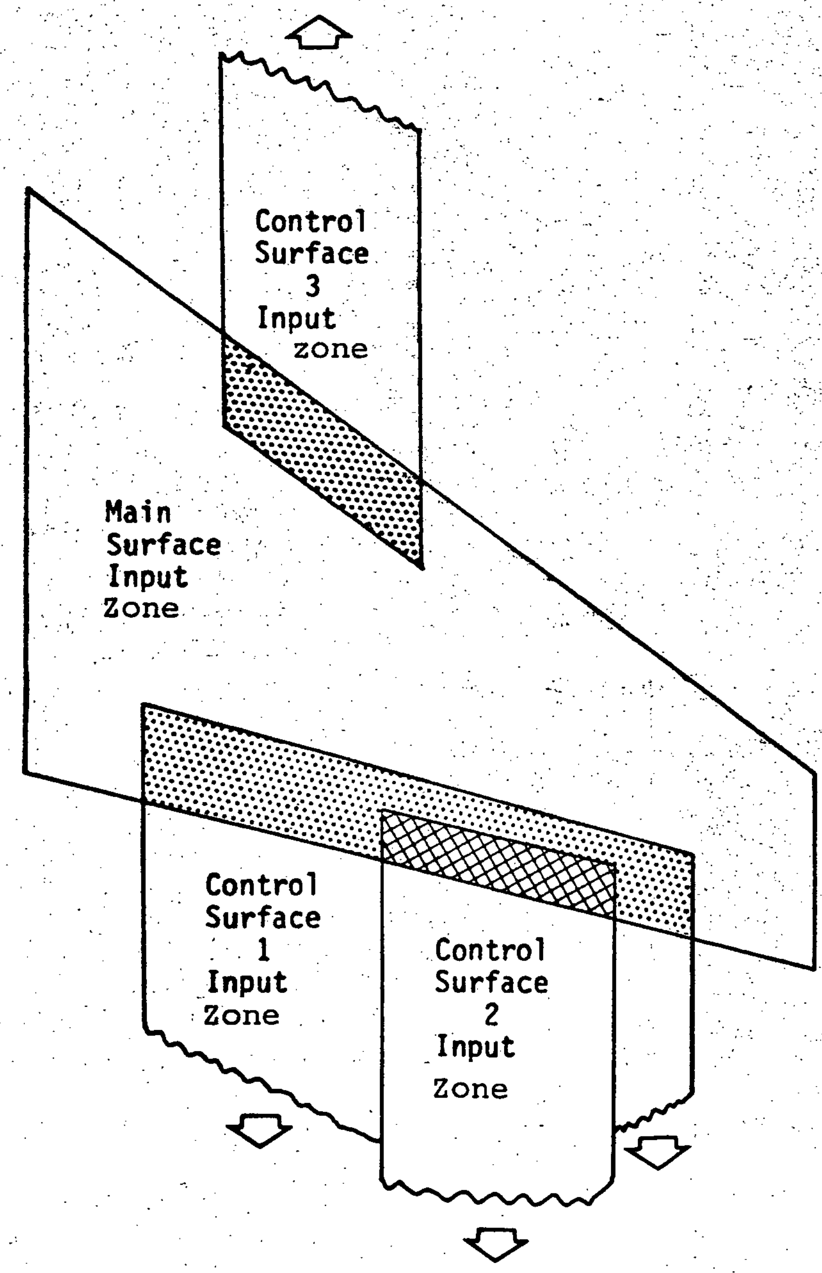
Solving the system of three equations and neglecting C,

$$\partial Z(x)/\partial x = B = [4Z(x_2) - 3Z(x_1) - Z(x_3)]/2\delta$$

Note that if the slope is a constant over (x_1, x_3) initially,

$$C = [(Z(x_3)-Z(x_1))/\delta - (Z(x_2)-Z(x_1))/\delta]/\delta$$

This procedure should reduce the introduction of extraneous control rotations in non control rotation modes.



Modal Input Zones

Figure 8

REFERENCES

1. W. S. Rowe, M. C. Redman, F. E. Ehlers, and J. D. Sebastian: Prediction of Unsteady Aerodynamic Loadings Caused by Leading Edge and Trailing Edge Control Surface Motions in Subsonic Compressible Flow -- Analysis and Results, NASA CR-2543, May 1975.

2. Ira H. Abott and Albert E. Von-Doenhoff: Theory of Wing Sections. McGraw Hill Book Company, Ic. (1949), page 341.

3. Zdenek Kopal: Numerical Analysis, John Wiley and Sons, Inc. (1955).

4. National Bureau of Standards Applied Mathematics Series .55, Handbook of Mathematical Functions, June 1964.

5. Robert L. Harder and Robert N. Desmarais: Interpolaticn Using Surface Splines, Journal of Aircraft, Volume 9 #2, February 1972, pages 189-191.

6. Technical Report R-48, National Aeronautics and Space Administration, page 8.